EXPLORING THE STRATOSPHERE

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by

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THE STRATOSPHERE

The New Idea.

OURS is a new age. We take that remark as platitude. That shows we do not realize our age's originality. No new age really understands when it has broken with the past. The change, if it is great enough to make a real break, is too great to be taken in at once by those to whom it is happening. We are living in a time of change only to be compared with the age of Galileo and Copernicus. In their period people found it almost impossible to accept what they had done. To accept as a real fact that the earth had no foundation, but spun, a flying speck, round the sun—that was a shock to common sense which it took generations to overcome in the minds of practical men. That idea, however, at last sunk in to men's heads. Finally it was taken for granted as a common-sense picture of reality. Children were taught and accepted it, as they were taught and accepted the fact that their blood

was circulated by their hearts. To-day, however, the Copernican-Galilean picture of the universe is being changed, revolutionized. We are, in fact, living through a revolution in our theories of the universe as great as the revolution through which men lived at the dawn of the modern age, when the picture of the universe centred on the earth was given up for a picture with the sun at the centre. This is such a shock to us that we find it hard to take in. We took for granted that we should never again have to change our minds and our outlook about the universe. We felt a certain pity for those last medievalists who opposed the new knowledge found by the telescope in the heavens. We were sure of two things. Our first assumption was that we would never have behaved as they did, and that any new theory would be easily and frankly accepted by us, if facts supported it. Our second assumption, quite as strong but not necessarily reconcilable with the first, was that the Copernican-Galilean picture had come to stay; it was absolute objective truth and could never be changed.

The profound originality of our age is then shown by our reaction to that originality. To most of us this change is not even unwelcome: it is so unsettling as to be almost inconceivable. We are living in the dawn of what can only be called man's Third Cosmology—man's third fundamental idea and picture of the universe as a whole and of his position in it. The first Cosmology lasted down to the time of Copernicus

and Galileo. It was the picture which showed the earth as the centre of the universe and man the purpose and climax of the earth. The second Cosmology showed the universe as centreless—for the pictures of the sun as the centre, or even with the Galaxy as the centre, were hardly made before astronomical observation showed they must be abandoned. The second Cosmology was also as unable to find any purpose in the universe as it was unable to find any centre. Man and his mind, life and its evolution, seemed only a peculiarly insignificant accident—the rarest and minutest freaks in a cosmos which otherwise was as uniform as it was pointless. It was clear that the second great universe picture could not make head or tail of consciousness. Mind had to be dismissed as a meaningless exception to the otherwise unbroken general rule. This was a queer conclusion: that the very person who explained the whole had to own that he had no place in it—that he and the causes which had brought him about were inexplicable and irreconcilable with the main explanation. This main explanation was accepted because all the experts said all the other facts fitted in. Life and mind, minute phenomena hidden away on this speck of a planet hiding near a second-rate sun, were the only exceptions to the rule of those laws of the heavens which study of the story had established. Even in the last century, however, some experts began to doubt this. Clerk Maxwell, studying light and electricity, showed that

these things did not fit exactly into the rules of the universe which Newton had made from the picture of Copernicus and Galileo. Theories, however, seldom can upset the pictures we have formed in our minds. Until to-day all of us, except extreme and abstruse theorists, have accepted and still cling to Galileo's picture, or what has been called the Second Cosmology. We cling to it as a true and exact account of reality itself. We shall only realize what is happening to us when, instead of theories, facts turn up to show that the old picture and pattern is melting and a new one is forming in its place. That is happening now. A third, vast, embracing idea of the whole universe, the whole of reality, is to-day forming in the human mind. It is being hastened forward by Stratosphere exploration. That is the first great reason why discoveries in the Stratosphere are so important to us. From the Stratosphere we shall get evidence of the new universe-picture which is now forming in man's mind. Through it will come the information and proofs out of which that picture will be constructed, and we shall be able to step outside that rut in which we and our imaginations were embedded.

The New Exploration.

We are, then, living in a new age, a third great period of man's thought and outlook: and as the second great period, the vast expansion of thought from Copernicus to Newton, opened men's minds when they were shut

fast against any theory, by making them look, look at the heavens and see what actually happened there, so our new age is advancing and can only advance by actual exploration of the sky. Theory is well enough for theoretical minds; practical minds must have actual finds—they must try and see. And this is sound science. Science is empirical. It advances because it will accept anything that can be shown to happen and it will not build on anything which cannot be shown to happen. We are beginning to realize how much our picture of the universe has suffered from the fact that we have always taken that picture from the same view-point. We have still been provincial in our outlook when we thought we were being supremely detached. It is not merely an accident that Copernicus's theory and Galileo's astronomy also belonged to the age of Magellan's circumnavigation of the earth. The theory that the earth was a globe spinning in space received second-hand confirmation from Galileo's telescope. It received first-hand confirmation from Magellan, whose fleet was actually circuiting the earth in the very decade that Copernicus summed up his arguments. Since then really original exploration has been over. It is true we have opened up countries which had been closed, scaled peaks which had been unscaled by man, entered one or two "new" continents —Australia and Antarctica—and mapped in broad outline the two poles which till our age had remained inaccessible. But all this exploration had only con-

firmed the first great exploration discovery of the modern age, Magellan's discovery that the earth was a globe and that all man could do was to travel round it indefinitely. We were confined in a definite area and could never change our standpoint radically. It was quite clear, once Magellan's discovery was made, that all future exploration was henceforth to be limited. We must, henceforward, steadily use up all the possible new paths and ways until the whole surface of our strictly limited field was known. That is what has now happened.

Fifty years ago, if a man wanted to lead a life both scientific and adventurous he became an explorer. There were the North and South Poles to be found—there were strange tribes still to be discovered in New Guinea, in the Brazil Forests, and the upper waters of the world's greatest river, the Amazon, to be tracked. There was a mysterious culture, only known by pre-scientific stories, to be studied in snow-bound Tibet. And beside the dense forests and the snow-bound heights, the deserts also held secrets. The Sahara was still in the main a huge blank on our maps. Even in Arabia there was a vast, empty, unmapped space. Hidden behind these blanks, rumour said, there were unknown peoples, unsuspected animals, and unimagined countrysides. The known world, the world of traffic-crammed cities linked up by road and rail across countrysides thoroughly farmed, that familiar world had still another side to it. There were hidden races

cut off, living in quite other ways, and vast wildernesses where men had never come.

That gave an exciting background to all our familiar and dull surroundings. It made our civilization still something of an adventure—an unfinished story. At the first glance it might look so settled, secure, and complete, that nothing exciting could ever happen again. But looking round the corner you saw that was only appearance. Indeed the whole of our well-known world was more like a huge " cinema set " than something solid all through. If you walked behind the frontage you found on the other side, stretching away, quite different country. Fifty years ago people still could fancy that somewhere where the maps were still blank might be found other civilizations, such as Rider Haggard wrote about being found in central Africa, and, even later, Conan Doyle imagined a lost piece of land in South America where Neanderthal man of the old Stone Age, and even the giant dragon lizard of still much earlier ages, might be surviving. It is only in our time that that hope has vanished like a mirage. It is odd but true that our most wonderful travel invention, the aeroplane, dissolved that alluring hope of further travel. Till then advance had to creep along. The road and rail could only be pushed forward yard by yard, month after month. The aeroplane at one leap has literally put the world at our feet. The arctic explorer scans at one glance, and with one camera-shot records, hundreds of miles of hitherto

unknown land. The same instantaneous record is got of waterless desert, impenetrable jungle, and unscalable peak. When the air squadron rode right over Everest the earth had no longer any ramparts that man could not leap on his magic horse, and there were no secrets which his magic eye, the camera, could not reveal and map in a moment, to be studied at leisure.

That, of course, has been a triumph, but it has also been very much like Alexander's triumph—though on a still larger scale. Alexander wept when he found he had broken right through the Persian Empire, the whole known world, and come out on the other side. He had penetrated clean through into fabulous India and it was much the same as anywhere else. There was nothing more to conquer. The world, it was clear, held no more wonders. Victory had defeated itself. Instead of opening the way to even more amazing worlds, it had showed that the whole world only held much the same sort of people and much the same sort of places.

We are then living in an age that has had a great disappointment, an age which has lost one of the great excitements of living—the hope, the belief, that all the dull, ordinary, and familiar things and ways are only a very small part of all that is. It is quite clear we are disappointed and at a loss.

If that were not so, we should not be so oddly anxious to "reserve open spaces," to make "nature reservations," "national parks," "game parks," etc. No

other age has ever thought of doing such queer things. They did not fear that nature might be crushed by them. They feared they would be crushed by nature. They all thought towns were good things, and wild, empty, "undeveloped" country was gloomy and "horrid."

Then came our age, the age of exploration, when people pushed out excitedly to find strange places where civilized men had never come before. And now that exciting advance has come to an end. Like children let out in a strange garden, we first rushed excitedly about shouting to each other that we had found a new thicket, an unknown pond, an unsuspected path. But now we are coming back tired and bored. We know the whole place. There is nothing new to be found. And, worse still, what has been found will soon all be made to look exactly like what we have always known.

We see, after all, it is literally true, we are only nits creeping round a great melon. Round and round we go and we can never get further; we cannot even fall off. We can move faster, but the faster we move the sooner we get back to where we started, like a donkey careering round the peg to which it is tethered. We are confined to a tiny film of air. The air we can live in stretches some 24,000 miles in every direction to and fro, but less than five miles upwards. The film of sea and air is so thin that in proportion to the size of the whole earth it only amounts to about as much water as will cling to a wet football.

This fact has, of course, been known to every educated person for a very long time, but only to-day have we, as Americans say, really found ourselves distinctly up against it. Till now it meant no more than saying to a person, who is living beyond his means but still has plenty of cash in hand, " some day you will be bankrupt." Even for the last generation there was still so much exploration to be done, and exploring had to be at such a snail's pace, that no one thought that it could ever possibly be finished and over.

To-day it is over, and over for good: the faster we go the sooner we are finished. This, however, should not lead to discouragement. The end of exploration means that we in our generation have finished the task which Magellan began. We have dotted every *i* and crossed every *t* on the draft he drew. We have completed a step in man's discovery and are now ready to take a completely new one.

Our new theories of the universe make it quite clear that we are about to take that new step. Copernicus's epoch-making theories about the universe are paralleled in our day by the new cosmologies of Einstein, Lemaître, and Eddington—which are as startling and inconceivable to us as the world-picture of Copernicus was to the ordinary cultured man of the sixteenth century. Galileo's equally disturbing observations of the stars are at present matched by observations indicating that the whole universe of stars and space is expanding so fast that it may be said to be exploding.

Magellan's circumnavigation, which destroyed the old small picture of a flat earth, must also be matched by a similar adventure to-day. It begins to be clear that if we really could move in a completely new direction we might not only get actual practical confirmation of the strange theories and strange observations of our astronomers and mathematicians, but we may actually be able to realize what they mean to us—as we never shall if they remain just theories supported by minute observations.

It is certain that our age has to strike out in a completely new direction. We are called on to do this under a double urge. Actual exploration on the level is closed. Theory and indirect observation are pointing out to us that our present picture of the universe is inadequate, and even mistaken. We must take up new positions so as to make those further observations without which we cannot reconcile into one picture the facts we now possess. We realize we have been too provincial. We have taken for granted that our picture of the universe was "objective"—that wherever we moved we should find things exactly as they looked from our particular local point of view and standpoint. Science now increasingly doubts that objectivity.

Still, how are we to take another step forward and get a more detached view of things? Two vast obstacles seem to stand in the way. One is theoretical; the other practical. The theoretical difficulty is that

it seems as though we have already looked through everything. What would be the use of changing our position and finding a new look-out point ? Is it not as clear as a frosty night sky that there is nothing more of a radically new nature to be found, even if we could voyage in directions men have never followed before ? Do we not know that only space and stars—flaring gases and utter emptiness—go on for ever, or at least for such enormous distances that even if we could move with the speed of light we should, at the end of our lives, and at the end of our civilization's life, only find ourselves in exactly the same desert ? By going to see, even if it were not completely out of the question as a practical proposition, we should add nothing to what we have seen and known already.

That objection to the new urge and call for actual exploration seems common sense, but it is not true. Seeing, it is true, is believing, and the only believing the elder science thought possible. Seeing seems to show that there is no case for further actual exploring, but science to-day is inclined to attach increasing importance to the second part of that well-worn proverb—Seeing is believing, but feeling is knowing. Science is beginning to realize that the most valuable and fundamental things it studies are themselves not seen and must always remain unseeable. It is becoming clear that the universe is full of forces which do not affect sight or, indeed, any sense, though life responds to them strikingly. Outer space is no longer

thought of as empty. It is only empty to our eyes. All the evidence indicates that it is full in a way which makes our atmosphere seem comparatively empty. Our instruments, which are far more accurate and searching than our eyes, record the fact that space is full of an immense force; and these instruments suggest that that force, and perhaps many others, come within a few miles of us and then are stopped by a screen behind which we live. It would therefore be worth while going through the screen, if we could, for a journey of a few score miles would probably reveal a completely new and, till lately, unsuspected state of things.

The first objection, the theoretical objection, is then out of the way. There is enough evidence to suppose that something very well worth finding exists quite close to us, if we could only get to it. We have, because of our position, overlooked something of supreme importance, something which may give us a completely new notion of the universe, and prove to be the first step to a new cosmology. Seeing has not been enough. Our eyes have been too simple and cocksure. There is something of great importance which they have failed to notice. This radically new thing can only be discovered, either by sending recorders more sensitive than our senses across the new frontier, or, best of all, though most daring, by actually travelling with the instruments into the new sphere.

There remains, however, the other grave difficulty.

It is clearly worth while trying to change our position radically. There is something really new to be found and explored. Can we ever hope actually to be able to do so? Are we really bound for good and all to the tiny film of air-space in which we have always lived? So far the calculations of science are very discouraging.

The limits to going down.

Could we go down? Hardly at all. True, the new "echo sounding gear" tells us the sea is deeper than we thought, perhaps nearer nine miles at its deepest than the seven which had been the estimated limit. But we are such egg-shell creatures, that the deeps of the sea are shut away from us more securely than if guarded by 12-inch guns. Dr. Beebe has gone half a mile down in a steel ball, down into complete blackness, down into pressures so crushing that beside them the blow of the heaviest steam-hammer would only be the flick of a feather. The depths of the sea therefore offer us little, even though they are only, at their deepest, nine miles. Going down, we can only hope to find eternal blackness and a pressure so great that we have to coop ourselves up in the heart of a steel ball if we are to creep down even into the first mile of it.

The depths of the earth are even more discouraging. The deepest mine is the Johannesburg gold mine, which goes to a vertical depth of only 3,380 feet. Here our delicate bodies are banned from going on, not by an almost icy pressure, as in deep diving, but by heat,

as the temperature increases five degrees for every thousand feet down. It is clear, then, that even if we could overcome all the immense practical difficulties which confront us in boring down to such depths, the heat of the earth would drive us back quite soon. No: the down track is marked "No road for humans." The calculations of science were right. We, delicate little creatures, must stay on the surface. Nor does science appear to promise that if we could go down we should find conditions and obtain records which would open up a completely new picture of the universe.

Obstacles to going up.

And up? There, too, calculations seemed to indicate that the road was barred. For if down you would be baked, up you would be frozen stiff. And more, if down you would be crushed—up you might burst. We take for granted the conditions under which we live. In point of fact they are extemely odd. We say "light as air," and when the Royal Society was started by Charles II. nothing that they did seemed more ridiculous to men of common sense than that these scientists should be trying to weigh air. Yet now we all know that the air normally presses on us with an enormous weight—more than fourteen pounds on every square inch of us—which means that the whole surface of each of our bodies is carrying a burden of something like fifteen tons. Of course this does not matter, it is literally inconsiderable—so long as

we stay where we are, where we are naturally adjusted to carry that amazing load. The moment, however, we move out from under this load, by rising up through the air that is piled above the earth, then we begin to suffer. The deep-sea fishes burst when brought to the surface. So we also would die, if taken suddenly up an equal distance out of our natural pressure.

But long before the air grows too light to keep the balanced pressures of our blood, etc., in proper play, it grows, even more quickly, too thin for us to breathe and also too cold for our blood to circulate. Suffocate, freeze, and burst; those are the three threats which nature makes if we dare try and step up above our station, above the crawling ground-level on which we are fixed.

Still man is an adventurer. Danger never keeps him back. Now all the other "level" paths are closed, and he can get nowhere by going down, the upper way is open, and take it he will. Science has warned him that it is very perilous—but it is the only way. Hence it is that our age is looking more and more to the sky as its new opening. The way up is the one way now open to exploration. There is a goal worth seeking. The prize which lies at the end of that road is a new picture of the universe. And it is also a way which, though dangerous, is not impossible.

There is also something to encourage us. Calculations have proved right about the impossibility of going down. Actual mining has shown that the heat does

increase as was estimated. But as regards the other extreme, the anticipation that it would continue to become colder with increasing height, there calculation has had one of its queerest checks. The higher, the colder—that seemed both science and common sense. You would rise up in your balloon and the mercury in your thermometer would creep down. Now it is that simple picture of the sky above us which exploration of the atmosphere has upset. Actual air exploration has brought to our knowledge two unsuspected facts, which calculation did not foresee and which common sense would have rejected. The first is that the air lies in great layers, as sea and air are in separate layers, or like stratified rocks. The second fact is even more surprising: cold does not go on continuously increasing with height. We will come back to that amazing fact and what it means later on in this book. Here and now we must attend to unsuspected fact number one: the fact that the air does not really mix, but lies in great layers round the earth. For it is this fact which made us first aware of that strange new region—the Stratosphere.

What is the Stratosphere?

What is the Stratosphere? Fortunately its name is a descriptive name—which is not so common in science that one need not be grateful for it and can simply take it for granted. Its nature and why we should take an interest in it explains its name.

As an authority on this queer unsuspected region has said, the most striking discovery ever made in meteorology (the science of the weather and the weather-sky) was the discovery of this sphere—the Stratosphere. It was made by a French scientist called Teisserenc de Bort.

At the end of last century, when aviation was in its infancy and ballooning was a sensation, meteorologists conceived the idea of using balloons to record the direction and speed of the wind at different heights. As it was obviously impossible to obtain sufficient data by manned balloons, small sounding-balloons were released bearing a light cage containing self-recording instruments. This was comparatively inexpensive, and from a great number of these, and by the co-operation of many observers, valuable records could be compiled.

These small instrument-carrying sounding-balloons were first used in France in 1894, and this method of exploring the upper air was taken up by Teisserenc de Bort at Trappes.

By an analysis of the records of two to three hundred balloons he made the amazing discovery that at a height of about six or seven miles the temperature no longer showed a steady decrease with increasing height, but that, contrary to all expectation, it then remained practically constant at about 50° to 60° below zero on the centigrade scale.

Similar experiments were later carried out in

Scandinavia and in the tropics, and the discovery was confirmed.

It then became necessary to differentiate between the Troposphere or layer of air which we had always known, and the upper " isothermal zone " or Stratosphere.

With that short description of this new province we must now see how it fits in with our general picture of our earth and its air. As the earth cooled the water condensed into oceans and the air collected above. In consequence it is surrounded by these thin films of liquid and gasses, and life seems restricted within these narrow layers. A body smaller than the earth—such as the moon—does not seem to weigh enough to be able to hold on to its air and prevent its gasses evaporating off into space. Mars, larger than the moon, but smaller than us, seems to have air thinner than ours. We ourselves have already lost, pretty certainly, some of the lighter gasses out of our own atmosphere. We have then to look upon our world as wrapped in finer and finer coats of rarer and stranger airs, each with its own peculiar character. First there is our home-air, the breath of life. Up till to-day it seemed to give us lofty enough room to stretch ourselves. For it rides easily over the top of the highest mountains: even the crest of Everest is a full mile below the Troposphere " ceiling." And, further, all the mists and nearly all the clouds are down here in this familiar air of the Troposphere. Only a few rare clouds ever get out of

this lowest layer. But even when we have got above the Troposphere, when probably more than two-thirds of all the earth's air is already below, even then we have not yet reached the Stratosphere.

Before we can enter that next great area, we have to pass through a frontier—the Tropopause—a cushion or buffer layer which keeps the air we know from the strange air beyond. The discovery that the two main layers of the air were not only distinct, but have, as it were, a sheet put between them—this Tropopause—to keep them insulated, was made by our own famous meteorologist, Sir Napier Shaw, not long ago. The Tropopause is estimated at about two miles in thickness, but this is very variable. It is a transition area from the weather of the Troposphere to the static and weatherless state of the Stratosphere.

Then some ten miles above our heads we enter the new world, or perhaps one had better call it the new heavens.

But before going on to see what we have now learnt and are learning about the new sphere, we must notice another queer thing about its frontier. We have seen that these layers or spheres of air keep their places in an unsuspectedly distinct fashion—they keep themselves very much to themselves. At the same time, though they are quite distinct they are in no wise rigid. We can best compare them with a film of oil floating on a film of water. The water and oil do not mix, and there is quite a clear mark and line where they

touch, but if you shake the water the oil resting on it will ripple also. That illustration allows us to visualize another fact about the Stratosphere. Though it is generally found at some ten miles high, that height is by no means constant. First it was discovered that even above our heads, here in the temperate zone, the Stratosphere does not keep to a constant height. In fine still weather it will often withdraw more than a mile and a half above the level it usually keeps in our ordinary "unsettled" or variegated weather. Then when the first upper air tests were taken in central Africa it was discovered that on the Equator even the insulating layer underneath the Stratosphere—the Tropopause—was not entered until you were over ten miles high. We have then to think of this new sphere as an elastic envelope which is always stretching out and drawing in, and which is blown out into a more inflated belt round the earth's middle.

This may not seem a very interesting picture, though in a moment we shall see that it presents us with so many problems and questions that it leads us to a completely new outlook on the world we live in. But first let us recall what, till this generation, was every one's belief about the atmosphere. We must realize how greatly our assumptions have been upset even by the few facts so far considered. As you go up through our familiar air—the Troposphere—the temperature drops steadily, and so we imagined it went on and on, until the ultimate cold of inter-stellar space

was reached. But the actual story has turned out to be quite different. As you pass the frontier and get into the Stratosphere it is already abominably cold, some 55 centigrade degrees below freezing, yet still an immense distance above the lowest limit of coldness, which is some 273 centigrade degrees below zero. And your thermometer is only some six of seven miles above the earth. On it goes, ten, twenty, twenty-five miles, but it still registers that same very cold, but far from coldest figure—some 55 centigrade degrees below freezing. That came as a shock. Whatever strange changes and surprises might lurk round other corners—whether, for example, down in the earth the heat may not increase in the way calculated, or whether the chilly depths of the sea may not be as cold as we expect—up in the sky all seemed plain sailing. It was surely impossible that any surprises should be lurking up there. Where could they hide? You would see any strange "change of state." But the upper air was transparently clear. Nevertheless there, just outside what had been man's farthest reach until this generation, there was lurking this unbelievable surprise—a surprise so great that our grandparents would almost have called it a breach of a Law of Nature.

It is worth while, then, pausing a moment over this, the first discovery made in the Stratosphere, before going on to others quite as remarkable, because it is perhaps a better illustration of the new outlook than any other find made in our wonderful generation.

We are beginning to realize the error of that old and really rather dull idea about science, the idea that when you have found out the first two or three steps all the rest will go on straight away without any change. We now know that this assumption, or what is called extrapolation, must be used with extreme caution, for natural laws do not go on dully and straightforwardly like a road across a plain. Because the first three or four cases were all in a line, you cannot say the next will be anywhere near that line. It is that very important principle which the discovery of the Stratosphere has illustrated most strikingly. It reminds us that true science is and must always be based on actual and constant observations, and that calculations from preliminary facts do not necessarily reveal the truth.

When science is going slow, counting up its gains, putting its many observations in order and making big classifications and collections under which to arrange its vast number of discoveries, then scientists are apt to feel that all facts must fit into the classifications. If the classifications are successful and practically all the facts seem to fit in, then everything which does not have a place in these beautiful systems is thought to be untrue or misunderstood. These systematists are like people with such very expensive and elaborate stamp-albums that they would refuse to recognize a new "issue" because their album had no places marked for it.

The discovery, then, that even the brightly lit and

transparently clear upper sky was all the while hiding a first-class surprise, a flat contradiction of all common-sense and reasonable expectation—that discovery is of first-class importance, not only as a new addition to knowledge, but because it points the way to a new age of science. We have to go ahead with more open minds than even scientists had in the past and expect to meet still more surprising and unsettling facts.

How utterly unlike the air we know.

We have, then, the first broad and very plain outline of the Stratosphere—our next realm of conquest and sphere of influence. It is indeed the plainest of outlines, exactly like those coast-line sketches or charts a surveyor on a ship might make of flat unknown land. We know the frontiers—stretching from some seven miles above our heads on for some thirty miles farther. We know between those frontiers lies a more or less uniform area. That is all. But it is enough to make explorers wish to push into the interior and find out more. It is already clear that this strange area is a place about which it is not safe for us to make any assumptions. Exploration—not expectation—alone can guide us.

Indeed, practically every expectation, every supposition, about the Stratosphere has been mistaken and has been belied by actual test and discovery. Even this comparatively simple question of temperature, of the Stratosphere's heat, the further we study it

the more complicated it becomes. For a time some experts thought that this temperature was constant all over the earth, but the more the Stratosphere has been sounded the more variations in temperature have been found. The present findings seem to show that the temperature of the Stratosphere which over-arches the tropics is constant at some 53 centigrade degrees below freezing, while the Stratosphere which domes the poles shows a very fluctuating seasonal change—in January it sinks to 61 centigrade degrees below freezing, while in July it has risen to 46 degrees below. So that in summer the Stratosphere above the North Pole is some seven centigrade degrees warmer than the equatorial Stratosphere.

We have seen how unbelievably wrong we were about the coldness of the upper atmosphere. But we made another assumption which was equally natural and not less mistaken.

Intense cold, in an air so thin that it is quite breathless, so thin it can hardly carry any sound-wave and all is silence, that surely suggests a stillness as intense. A full mile and more above the highest peak, above the dusts and the sprays of mists, above the clouds, surely up there must be "that sacred everlasting calm," brooding above this noisy, stormy earth-level, as the early Greek scientists had imagined.

This was still unquestioned, even when experiment had begun to show that the Stratosphere was a place or condition of things quite unlike anything

we human beings had ever known and where our assumptions were apt to be of no value. Even then we went on assuming that the Stratosphere must be calm and windless. Even if it did not continue to get colder in the common-sense way it must be still, because what sign was there of it being disturbed and what on earth would be able to disturb it? And there was a reason for wishing so to believe. As we shall see later, when discussing the use to which the Stratosphere may be put, there have been quite considerable hopes built on the windlessness of that next storey or upper level of the highway of the air. Already aeronauts have begun to talk a great deal about Stratosphere flight, and all that talk has so far been based on this assumption that the upper sky is windless. It was, however, nothing but an assumption, and—as we must always find with assumptions—one fact, one observation, has blown away the hope.

The Stratosphere not only has its own queer temperatures: it has its own queer wind. How that was discovered we must see in a moment. We must at present be content simply to put down this new fact—the second fact we have found out about our new area of exploration.

The Stratosphere has a cold which is intense, but with unsuspectedly little variation, and perhaps none above the tropics; and it has also winds which are tremendous, and probably of a persistence, as well as of a force, we hardly know down here. A two hundred

mile an hour wind, a super-hurricane, has been watched tearing along up there. Whether this is an exception or a rule we cannot yet be sure. It seems, though, that if such a wind can get under way up there, there is very little reason why it should die down, and so perhaps we are fairly safe in assuming that such a breeze is as natural up there as are sea breezes on our coasts. But again we must be careful: we know so little in actual fact, and supposition and theory so often and so completely deceive us. Dr. Piccard has said, and his opinion, as the first stratonaut, is weighty, that he believes that at various levels in the Stratosphere gales of various speed are always blowing—giant brothers of our Trade Winds down here. We also know that a two hundred miles per hour wind can rise there and spread over a considerable area, though we cannot at present say for how long such gales can blow. That observed fact must affect all our further calculations and estimates, especially that big hope of those practical hustlers the aero-men, who are already getting ready to reach and try to use the Stratosphere as the super-intercontinental speed-way.

There is one more great discovery and observation to be mentioned. This third discovery was made earlier, but to people in the last century it would have seemed strangest, oddest, and most useless of all the three finds. Yet to us it seems most familiar, most commonplace, and practically useful. That is the fact that the electrical state of the Stratosphere is quite

unlike the electrical states we know in our part of nature.

Broadcasting has made all of us almost boringly familiar with the Heaviside layer. Those of us who are old enough to remember have forgotten, those of us young enough to be born since have hardly troubled to memorize the important historical fact that when Marconi discovered " wireless " and made it work, he was doing something which pure scientific knowledge then announced was quite impossible. Further, he only succeeded because there was in the upper Stratosphere in the daytime a something which neither the official scientists nor this brilliant young unorthodox researcher knew or imagined could possibly be there. The upper layer of the Stratosphere in the daytime becomes the home of the Heaviside layer—the invisible, intangible vault of the sky on which the radio waves can echo, rebound, and so go round the earth carrying broadcasts, which otherwise would rush straight off into unreceptive, echoless, interstellar space. But it is only during the daylight that the Heaviside layer comes down into the Great Loft, the Stratosphere. Then the radio-carrying layer will stoop towards us until it descends as much as half-way across the Stratosphere, as far down as twenty-five miles above our heads. At night it withdraws from the Stratosphere and rides some sixty miles aloft.

This fact, that the upper ranges of the Stratosphere are always, day and night, being invaded and evacuated,

flooded and ebbed, by a vast electric tide, has become a commonplace to our practical radio-age. Yet we should not let familiarity breed contempt. We use this mysterious, impalpable, and invisible tide or breath —the vast diurnal respiration—to carry our little messages. We are in danger of being so pleased with the practical use we have found for this immense, inexplicable phenomenon that we may forget how little we know about it and how further study may lead us to even more amazing, utterly unsuspected, and disconcerting knowledge. What seems already coming to light is that the third discovery about the Stratosphere, its strange electrical condition, may with fair certainty be linked up with the anomaly of its temperature and the tornado winds.

We are beginning to realize that that favourite phrase of the nineteenth century physicists—" after all, everything may be nothing but electricity "—may be more than a phrase. For behind every disturbance and below every appearance it looks as though there were always a distinct electrical condition. In this case the electrical state might give us the explanation of the Stratosphere.

The threshold to even stranger states.

Those three discoveries leave us then at the limit of the Stratosphere and looking beyond. If, as seems increasing likely, the unforeseen winds and stability of temperature are caused by the strangest of the

three conditions, the peculiar electrical condition of the Heaviside layer, then we cannot really hope to treat the Stratosphere as a study by itself. True, it is a strangely isolated region, a huge airy continent; but, when earlier we compared it to an unknown land which a seaman might survey from his ship, that was to make this great loft too distinct. No island has a coast which continually bulges and sags as the sea-tides bear in on it. A better simile, then, would be some huge wrack of sea-weed, like those tangled banks met wallowing, many a rood, many a mile, in the Sargasso Sea, or, if we prefer a small picture rather than a big one, it can be likened to an oil film heaving and falling on rippling water. Anyhow, what we have to keep in mind is that here is a region which man has begun to sound, into which he is at last himself beginning to make his first adventurous dives, and that region has strangely different conditions from the conditions we have known and have expected, and that these surprising conditions owe more to what is beyond and above the Stratosphere and less to the atmosphere we know so well—the down-here of ground level.

We must, then, keep that fact in mind when we think of how and why we carry our explorations above the Troposphere, in which men hitherto have spent all their days. No doubt we shall make some remarkable uses of this new area, both beneficial and dangerous. The uses, even if they are wholly beneficial, will, however, be secondary to the pure knowledge we shall gain.

Surprising as have been some of the first pieces of knowledge we have won from what has so far been considered empty sky and practically airless space, still the Stratosphere is only one storey above our well-known home-level, and above it we may expect to find states even stranger and more strangely significant. Indeed, it is no closed sphere; rather, it is a threshold and gateway to more wonderful knowledge. It, like "all experience, is an arch where through gleams that untravelled world whose margin fades for ever and for ever" as we move and climb. That is the goal and prize before us to which the Stratosphere points the way.

CHAPTER II

SCALING THE SKY

What man discovered by looking at the sky.

MEN had always been interested in the sky. It seemed absurd that birds, which were stupid animals, could mount the sky, and man, who was so clever, could not. The sky was certainly worth exploring. Across it moved the stars which, quite early, men agreed must be immensely powerful and important.

Indeed, anything in the sky made a peculiar impression on man. Clouds, he felt, were just as important as stars, and even flights of birds up there should be watched carefully, for they might discover to him some vital knowledge unobtainable on the level. And when science began with the Greeks, one of the first of these thinkers suggested that the sky might hold the secret of everything if one could really understand it. Air, said this Anaximander, is the foundation of everything : a very bold idea, and one which, if it had been followed up, would have led quickly to our present knowledge of the world around us. Unfortunately this idea was a little too daring, and it was not pursued. Aristotle, however, brought knowledge a step further by taking

up this clue again. He actually guessed that above the ordinary air in which men lived and moved and breathed there was an upper air of immense coldness, and then above that was another layer or sphere where the air again was hot. This last really amazing speculation has had some confirmation in the last five or six years. For Aristotle, however, it was hardly more than a guess with little knowledge to support it.

That, however, is to take us outside and beyond our Stratosphere. After the immense genius of Aristotle, no one made any real contribution to sky knowledge until the Arabs, who studied Aristotle, made the brilliant calculation, nine hundred years ago, that by noting how long the twilight takes to die out of the evening sky you ought to be able to calculate how high the air went. For it seemed to them that the sunlight, being caught and reflected in the air, caused the twilight, and where there was no air, there the sunbeams passed through leaving no trace, as the beams of a searchlight passing through very clear night air will be invisible until they strike some reflecting object. With this very simple method they arrived at the very respectable conclusion that the air must extend at least fifty-eight miles high. Even after the telescope was discovered by Galileo, the modern age added much more quickly to our knowledge of the stars than to that of the actual sky. For, as we have seen, the real difficulty of studying the sky is that you all too easily

see through it and so leap to the conclusion that therefore there can be nothing there—or at least nothing worth stopping for and studying. It is strange that the area where we can see least is the very place where actual exploration has told us most.

How we began to try and touch the sky.

The first steps, then, to our modern understanding of the sky were the kite, the balloon, and the flying machine. The kite must not be forgotten, for it was the means of a very spectacular discovery.

Thunderstorms had always interested men, whether savage or scientific. Nearly all early peoples worship the thunderbolt, for it is literally the most striking thing they know. And when modern men and scientists began to study the lightning they found that here, for once, early peoples had not been romancing and overrating this strange capricious force. Indeed, if anything, they had underrated it, so gigantic was the electrical charge found to be. But how did the vague and gentle sky manage to gather and hold such violence and then suddenly to discharge it like a gun? Benjamin Franklin, America's first great man of science, determined to try and see. He flew a kite into a thunder cloud and was luckily rewarded with only a small shock. It is clear to us that had he made too great a success with this first experiment we might never have heard of it—for kite, contact, and experimenter might all have been flashed out of existence.

The first height explorer.

The balloon next took up the trail, but for some time these very important practical experiments in the electricity of the sky were not advanced. Hunting thunderstorms, as it were with the naked hand, is rather more dangerous than hunting rhinos on foot with a spear. The famous scientific balloon flights of the last century were nearly all devoted to getting up as high as possible—choosing a fine still day and then, like a gossamer-spider, letting oneself go. The record of scientific heroism is well represented in these balloon plunges.

Thermometers and barometers were taken, but seldom any adequate protection for the balloonists themselves. Often oxygen was provided, but many pioneers died in their enterprise. For one of the great dangers of really high flying, rising into air too rare to breathe, is that the body fails us as unsuspectedly as when we take a well-given anæsthetic. The voyagers used to try and stick it out as long as possible to get to still untouched heights. They used to hang on, holding the rip-valve cord in their hand, ready to make the balloon descend. Suddenly they would fall unconscious and the balloon would carry them on up through the dazzling, soundless, breathless, freezing air to their strange but noble death.

The danger that unconsciousness may creep upon you without warning is so common that the transcontinental air-pilots in the United States are cautioned

when flying high to look once, every stated number of seconds, deliberately at some near clear object, say the edge of their cabin window, and if this does not appear quite clear and hard then to take at once to their oxygen. That slight mistiness is probably all the warning they will get that they are going off.

How instruments had to go up instead of men.

It was the impossibility of remaining conscious in such thin air that placed a limit on the height to which man could explore. The difficulty in climbing Mount Everest lies not in the actual climb itself, for there are many smaller mountains as treacherous and difficult, but in the fact that at such a high altitude every movement is an effort and the senses are dulled almost to inactivity.

But in exploring the upper air the records of instruments are no less important than actual personal observation, and the small instrument-carrying sounding balloons were invented to ascend and bring back information from zones where a man could not live.

The steady improvement of these sounding balloons has in itself been a rapidly growing branch of scientific discovery and upper-air exploration, and such balloons have reached a height of twenty-three miles in recent years. The first and simplest device was to send up on fine still days small balloons carrying " maximum and minimum " thermometers and then to advertise asking any one who found the wreck to send it back carefully

to the researcher who launched it. If it was found at all it would certainly be a wreck, for the gas in the balloon would expand, as the pressure of air became less, until the fabric burst under the strain and the cradle and instruments would fall and chance a lucky landing.

Very soon these sounding balloons began to be fitted with ingenious little parachutes which, when the envelope burst, themselves opened and so floated down to earth with the instruments. That kind of descent meant, however, an even poorer chance of recovery. To the drift of the balloon as it went up was added the parachute drift during its descent, probably greater, because, coming later, there was more chance that the calm weather, seized on for the launch, would have passed. This method, therefore, is only of use in continental countries which also have large populations. Then there is some reasonable chance that the balloon will come down on land and be found by some one who will understand its value. In America and Germany these methods have had a considerable measure of success. So much so that it was worth while constructing ingenious undercarriages and shock absorbers of split-cane to take the blow and save the instruments when they hit the earth on their home-run.

Sending up instruments not enough.

Nevertheless, even if the instruments were recovered after their descent, and were sufficiently undamaged to be read, it was hard to get from them any but the

scantiest picture of the strange areas through which they had travelled. Indeed, most could only say how high they had reached and how cold it was when the top of the flight was touched. A small balloon could never carry a sufficient load of self-recording instruments and be certain to return safely to earth with a full account of its journey. Such records as could be obtained are but a poor substitute for actual personal exploration. The only way out of the difficulty seemed for men themselves to go out to that deadly height, and there, under their own control, get their instruments to record.

The risks of Stratosphere exploring.

This was almost as dangerous a thing as man has ever attempted, and, as we know, Nature has taken as full a toll of these new adventurers as she has of any who have set themselves to uncover the secrets she has so long hidden from men. The thermometer showed the deadly cold which would have to be met. The barometers confirmed that the air was of suffocating thinness. Further, a still stranger possible danger had lately come to light—in the Cosmic Radiation. About this radiation—one of the most unexpected and stimulating finds of our generation—very little must be said here, for it comes from far beyond the Stratosphere, from the depths of outer space. Also, its main power, which certainly in open space would be highly dangerous for any life exposed to it, has

already been checked, filtered, and screened long before it reaches even the Stratosphere ceiling. Nevertheless, even there it is probably one of the dangers which the explorer into that complete unknown has to face. In the Stratosphere cosmic radiation is filtered, but far from sterilized. The courage of such men as Dr. Piccard, who will always be remembered as " the first who ever burst into that silent sea," cannot be underrated. For every one who has ever explored on earth may have had to dread savages, wild beasts, storm, and cold, but all these perils were familiar perils and man has long learnt how to shield himself against them. But those who go outside the range which Nature has provided for them face not only unknown perils—their own senses may there betray them. We have seen that consciousness may be lost before the victim realizes he is in danger, and further, we now know that when a person is " burnt " by X-rays or radium he does not feel anything or indeed notice any effect until many hours after. So, when men expose themselves to the Cosmic Radiation they are taking a risk, going close to a peril, like a blindfold man walking near the edge of a cliff. Why man should so much wish to know about this Cosmic Radiation, and risk his life in reaching the Stratosphere mainly as a step to further knowledge of this dangerous mystery, we must see later, when we are summing up the reasons for this exploration and how it may add to our knowledge as well as to our powers.

How Stratosphere Typhoons were sighted.

These perils were realized, and were satisfactorily guarded against by the explorers ascending in a light ball of aluminium inside which they could carry their own air, as the water-spider carries down its air-bubble when it goes under water. In this way they could keep from being frozen to death and also avoid the possible danger of being X-ray burnt without their knowing it. One peril, however, was not realized, and though it was the most commonplace of dangers, and one which has imperilled all voyagers from earliest times, it was thought to be absent and might well have proved most disastrous.

When Dr. Piccard made his great flights it was not realized that the Stratosphere, besides being cold and suffocating, and possibly "burning," could also be typhonic. Yet it would seem that these great gales have been found to blow up there. That, of course, raises a question: If Piccard and the other Stratosphere climbers have not yet run into such gales, and there is no evidence of sounding balloons having done so either, how have we discovered that the dead, clear air of the Stratosphere has cyclones rushing through it?

The way the gale blowing in empty air scores of miles away was detected is remarkable enough in itself, and also it is worth mentioning, because this particular study is one which has given us plenty of other strange information about the upper atmosphere. This is the

study of meteors, shooting stars. For example, it was the work of two meteorologists, Lindemann and Dobson, in this special subject that led to the surprising discovery that above the Stratosphere, after the temperature had paused throughout that vast belt, refusing to sink, like Joshua's Sun at Ajalon, the cold then, instead of increasing, actually decreases. It would appear that the rarest air is actually hot. Indeed the latest calculation seems to leave no doubt that at 150 miles high there can be the deadly temperature of 1,700 degrees Fahrenheit. This, however, is again to step over the line we have drawn for ourselves, the upper limit of the Stratosphere. Yet it was the study of meteors, objects which are mainly sighted well above the Stratosphere and generally disappear before they reach it, which gave us this particular piece of knowledge. So that not only can you watch the flight and fall of a balloon but you can also note the behaviour of the objects which Nature sends down. Nature is always pelting on to us from outer space stones, pebbles and sand, and iron grains and slugs. These, we know, burst into flame as they literally tear their way through, and wear themselves away against the air—even though it is so thin. Some of them are big enough to burn so grandly that, like rockets, they leave a glowing tail of incandescent dust floating for some seconds behind them. It was one of these huge streamers, probably scores of miles in length, which was watched and measured in the last few months.

It was seen to be rolling away like mist before a storm. The pace was calculated, and it was found that to sweep away this glowing train at such a rate a gale of 200 miles per hour must be driving along in what till then was thought by most observers to be the breathlessly still Stratosphere. Since then another of these meteor-caused Stratosphere streamers has not only been watched but photographed, and these photos tell us even more about the Stratosphere wind. For the luminous trailer cloud is shown bending into great zig-zags or spirals, as though at different heights of the Stratosphere contrary gales were blowing.

The Stratonauts.

We must now come to the actual voyages and discoveries of the first Stratonauts.

Most stories of exploration are difficult to tell, because they are so long over that no one remembers quite what happened. But this, the latest exploration story, is difficult to tell for the opposite reason—we are at this moment right in the middle of the adventure. As one writes, at any moment news of a new launch and a new break-through may come to hand, making all our present explorations out of date. Still we must try and see how the big push has been going, though we are still in the full rush of it. Dr. Piccard is here the great pioneer. His two plunges into the Stratosphere showed clearly two things. First, that his calculations of the means needed had been in the main

right, right enough to get him there and back alive. Secondly, his voyages showed that the calculations concerning the end, aim, and goal of the voyage had been mainly right also. Apart from the possibility of giant gales (which he was lucky enough to miss), conditions ten miles up were, for the most part, as estimated. That does not mean it was unnecessary to go there, to keep on going there, and to go still farther. It only showed the scientists were on the right track. For, once you had found that conditions up there might change with unexpected rapidity, it was necessary to go up with instruments so as to get a full and certain record of the changes encountered in passing over the invisible frontiers.

Dr. Piccard made many unusual provisions. First, there was the famous aluminium sphere in which he and Dr. M. Cosyns crouched with all their gear—that thin shell which protected them and now rests with other famous scientific trophies in the Science Museum at South Kensington.

Then, again, their balloon had so little gas in it that when it started from ground level it looked more like a collapsed umbrella than a proper balloon. That, of course, was absolutely necessary, for when the balloon got into really thin air the gas would expand, and if it were full when it started from the ground it would burst up there. Fortunately, these calculations again were sufficiently accurate.

On May 27, 1931, Dr. Piccard inaugurated Strato-

sphere exploration. He went, recorded, and descended. Before he began to make the balloon sink he had reached nine and three-quarter miles, by far the highest altitude any living man or any animal had reached. Nevertheless, even then, with all his precautions, it was touch and go. After that first epoch-making ascent he found he had been carried clean over the Alps—right down from Augsburg, where he had started—and when he saw he must come down, if he would count on saving his valuable records and himself, the balloon landed on a high glacier. It could not be recovered, and much of the records became unavailable. The first Stratonaut had got there and back, but it was as though, after finding America, Columbus had been shipwrecked on the Spanish coast and only saved portions of his cargo.

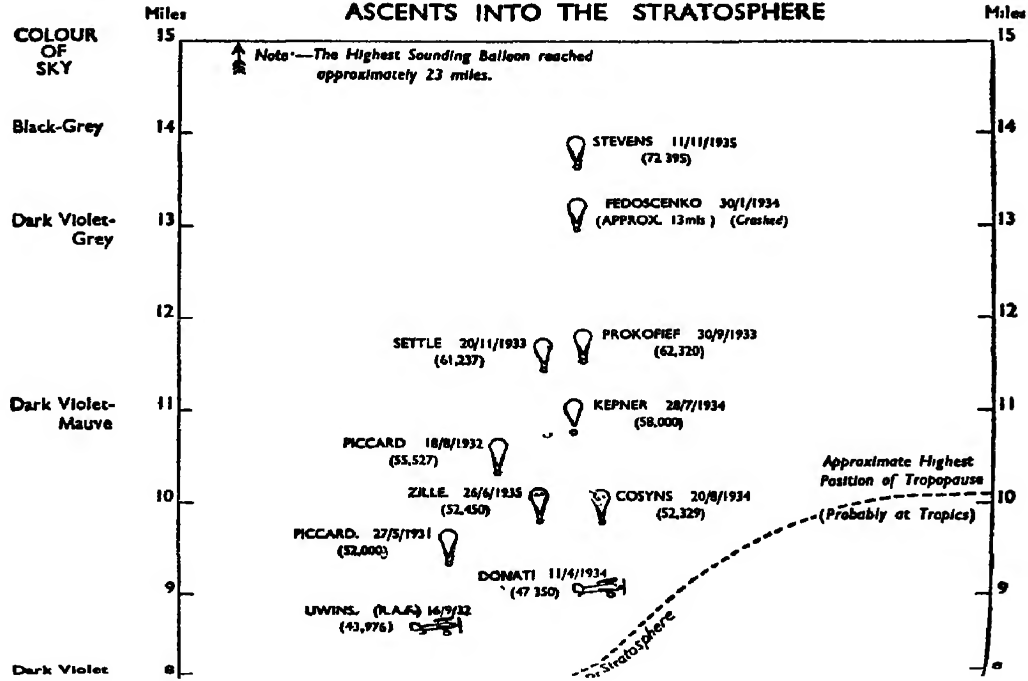
On his second flight he was more fortunate: he not only went farther but fared better, making a much safer landing. This time (August 10, 1932) he reached ten and a half miles, so beating his own record handsomely, and he managed after twelve hours' flight to come down not on a glacier but in a field on the Lombard Plain near Lake Garda. Yet again he and his companion had only just escaped. The cold was almost unbearable, and when they descended into the grilling, stifling, heat of an Italian mid-summer the Stratonauts nearly collapsed. They were asking almost too much of the human body.

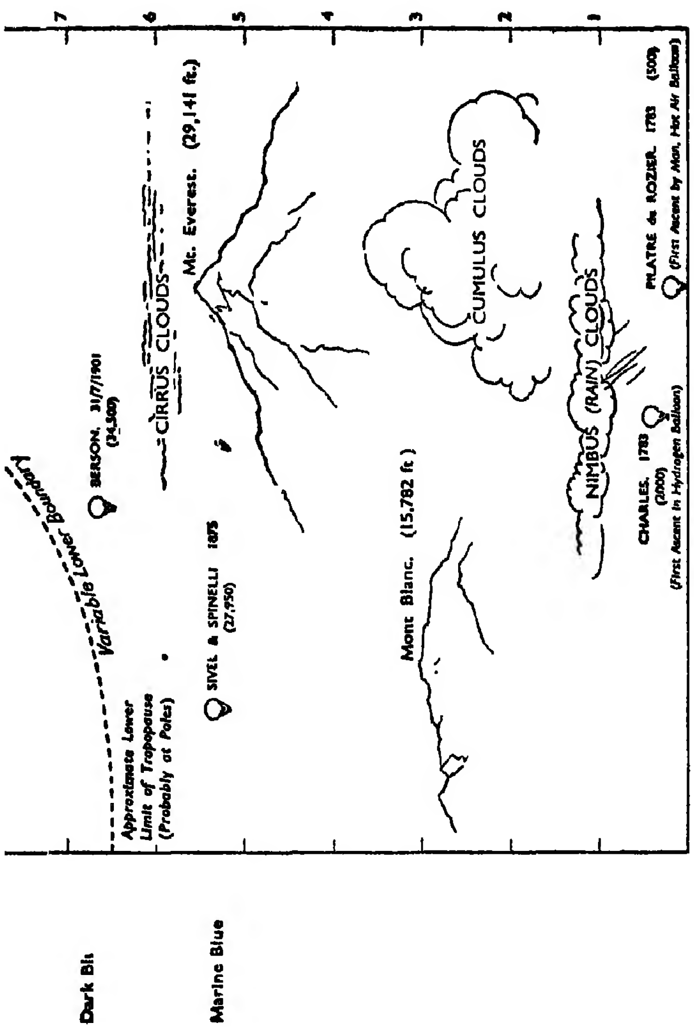
Still Dr. Piccard was amazingly fortunate. We can

be sure of that, for since then the Stratonauts have met with far worse luck. After the Russian, M. Prokofief, in October 1933, had reached nearly twelve miles and broken Piccard's record, the Soviet three months after (January 1934) attempted a still more ambitious plunge. This effort ended in complete disaster after having reached a greater height than had yet been attained. The balloon, *Syrius*, carried a complete equipment of instruments including wireless, and the crew maintained radio communication with their base practically throughout the flight. Amongst other information they carefully reported the changes in the colour of the sky as they ascended—from the familiar clear blue through purple to a blackish-grey. This was not altogether unexpected, for the colour of the sky is due to the scattering of sunlight by particles in the air, and where there is little air there can be little diffusion of sunlight. Most of the records of the *Syrius* were recovered, and show that the balloon was probably over thirteen miles up when it collapsed. Why—we shall never know for certain.

About the other great Stratonaut disaster, the failure of the United States monster balloon, in July 1934, we have more news. For there the explorers were able to hang on to their collapsing carrier until they had been dropped into breathable air. Then, with great resource, they released the parachutes and got down to earth safely. There was no doubt in this case that the fabric had burst, for a great tear appeared in the

ASCENTS INTO THE STRATOSPHERE




7
6
5
4
3
2
1
Variable Lower Boundary
Approximate Lower Limit of Tropopause (Probably at Poles)
BERSON. 31/7/1901 (34,500)
CIRRUS CLOUDS
Mt. Everest. (29,141 ft.)
SIVEL & SPINELLI 1875 (27,950)
Mont Blanc. (15,782 ft.)
CUMULUS CLOUDS
NIMBUS (RAIN) CLOUDS
CHARLES. 1783 (2000)
(First Ascent in Hydrogen Balloon)
PILATRE de ROZIER 1783 (500)
(First Ascent by Man, Hot Air Balloon)
Dark Bl
Marine Blue

envelope, and was watched as it gradually got bigger both by the Stratonauts themselves and from an aeroplane which photographed the flight. Why exactly it should have done so, what precisely was wrong with the calculations made in preparing and guarding against this very danger, we cannot yet be quite sure.

It seems strange that the same knowledge and method should have let Dr. Piccard's two expeditions be successful, and yet have failed in two efforts made after his successes. It may be possible that in each of these later cases conditions were reached where strains were present—gales, radiation, and even, in the Russian attempt, a tear caused by a pebble or grain of meteoric stone—which Dr. Piccard escaped.

One thing, however, is clear, and that is that danger is not going to hold men back. On the contrary, risk and the unknown always lure men on. Already the records brought back—partial and fragmentary as they are—show that there is much to be found there, much that is both strange and will pretty certainly prove useful.

The 1935 season opened with the Russians' ascent. After two "dips" into the Stratosphere in June the U.S.S.R., like the U.S.A., refusing to be daunted by disaster, at the very end of the month made a "full-dress" ascent. The scientists were, however, content with a two hours' rush, which had let them reach some 53,000 feet, more than nine miles. For by then the

Stratosphere had been attained, and after storing their instruments with records the balloonists descended safely by approaching near to earth and completing the journey by parachutes, and they made a safe landing only about 100 miles away from where they had started. It seems, however, this is an expensive way of Stratonauting, as there is too great a possibility of the balloon itself being allowed to become a total wreck. Much of this Stratostat was salvaged, but much was damaged. It reminds one of Charles Lamb's description of the earliest Chinese way of getting roast pork—by burning down one's house when a pig was inside it.

Meanwhile the greater U.S.A. balloon remained at the ready, still riding at anchor waiting for favourable weather before making its great venture to widen the limits of man's Kingdom of Knowledge.

So Columbus had to wait for fair weather—though to-day Atlantic crossings run to schedule. So the first scientists, the Greeks, had to hang about in their little bays until a favourable and easy wind would come into the gulf. One day it may seem as absurd to our descendants to wait about for a favourable spell before venturing into the vast gulf and ocean of the Stratosphere as it would seem to us to be unable to cross the Channel because of "contrary winds." They will smile at these limitations, but they will as surely reverence the courage which with such rudimentary powers dared so much and opened the way to those who came after.

Study of the wreckage of the American " stratostat " —*Explorer I.*, as it was called—has shown that not all the photographs and other records were completely ruined. Indeed they show quite clearly how the pelting of the cosmic rays (or particles) were increasing at 40,000 feet, and one electroscope was found still unsmashed recording what the electrical conditions were at 60,000 feet—well over eleven miles up. It grows increasingly certain from what has already been brought back that if we would know more about that mysterious and most puzzling Cosmic Radiation, we must go stratonauting up, time and again, and farther and longer; and as the Cosmic Radiation is one of the fundamental problems in science to-day, it is clear that up there lies a first-class prize.

And the study of the Stratosphere will help in a more immediately practical question, for there lies the best chance we know of at present of understanding the weather. The Cosmic Radiation may seem an abstract thing, but to be able at last really to forecast the weather—to know when droughts and deluges are due —that would be knowledge worth literally hundreds of millions.

The latest achievement.

Before, however, we consider all the reasons for which we need a knowledge of the Stratosphere, we must close this chapter with an account of the latest and most successful ascent.

The United States are less inclined than perhaps any other country to sit down under a failure, and a new balloon has been built and named *Explorer II.*, to take the place of *Explorer I.*, which crashed.

The envelope itself is " the biggest bag yet," having an area of 2¾ acres, a space on which a man could keep himself and a cow, and when fully inflated at its highest point, it holds no less than 3,700,000 cubic feet of helium gas. This gas can only occupy about 300,000 cubic feet at ground level, and so before its ascent the great swaying body stood over 300 feet high, like some fantastic gargantuan shrouded monster.

You would think that such a queer drooping net could lift little, but, on the contrary, it was calculated to lift at least eight tons.

Now that means that the skiff it drags after it can carry a really full-scale equipment of instruments, in fact a real laboratory. The cabin itself is nine feet across, and weighs when empty more than a quarter of a ton. Its equipment is, first and foremost, an 80-foot parachute. Then, with that sky-escape installed, come the instruments. Cosmic Radiation is the principal prey, and so much of the precious weight must go in instruments to track that. Three recorders (ionization chambers) were carried. These must be very heavy, because only by giving the rays something really dense to get through can you know how hard they are pelting. One of these chambers was sheathed in two inches and another in four inches of lead, and that one

weighed by itself almost as much as the whole cabin when empty.

A dial-thermometer, three feet across, was recording all the time at the top of the balloon, and the observers could watch their record-breaking by looking straight up to it through their cabin's top window and the great bag's vent.

For every imaginable happening, an instrument to record it was provided. The outside air could be continuously tested through a " chimney." The brightness of the sun, of the sky, of the earth, and the quality of the light—" invisible " as well as visible—coming off from all these areas, were continually recorded. Cameras at every angle recorded the height above the earth (to check up with the height given by the barometer), and the vast horizon, for more of the earth's shape was actually visible than ever before; and cinema cameras were ready to whirr off a moving picture of any event of which a pictorial diary would be of value.

Arrangements were made to sample the Stratosphere air and bottle it for study on earth, and slides were exposed on which any germs or spores in that rare air could stick like flies on fly-paper and be brought down to the microscope.

Further, it is known that life is still in some ways more sensitive than any instrument so far made. The famous fruit-fly, Drosophila, has already shown us that her eggs will give rise to very odd flies if they are exposed to very weak X-rays. This sort of investiga-

tion helps us to find out the laws of breeding, and so batches of these eggs were taken up and put to hatch in that queer " light."

Every care was taken in the preparation of the balloon envelope, which was made of a rubberized material, but despite all precautions, when it was inflated on July 11, 1935, in readiness for the first venture aloft, the fabric rent and the immense tent collapsed with such speed that those who were working on the gondola had only just time to run for their lives.

Undeterred by this mishap the balloon was repaired and the fabric strengthened, and on Armistice Day, November 11, 1935, in fine weather, Captains Stevens and Anderson of the United States Army Air Corps started on their record-breaking flight. The *Explorer II.* was released at seven in the morning. It rose from the Central State of South Dakota, and so had immense areas of land in every direction over which it could drift safely. It began to rise at 600 feet a minute. When, however, it had reached 21,000 feet the pace of ascent had slackened to half that rate. It was then, not till two in the afternoon, when the Stratostat had been drifted a couple of hundred miles south over the neighbouring State of Nebraska, that it attained its maximum height. It had safely broken all records, at last having reached an altitude of 74,000 feet—safely over the fourteen-mile limit. The former official world height record stands at 61,236, and the Russian record

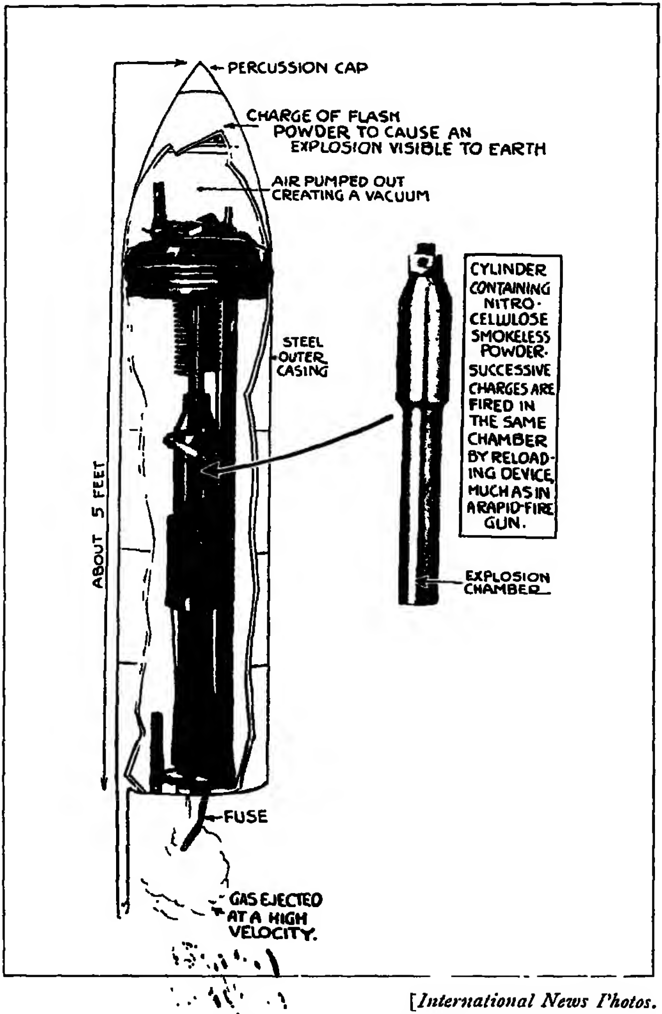
(not yet admitted as a world official record) is given as 72,176. Then Captain Stevens signalled by radio to the earth that he intended to return to it. This, which is fairly certainly the more dangerous half of the flight, was also safely effected, and he alighted having only drifted over the border into the state that lay south of him, Nebraska, and over which he had attained his summit. Before alighting, the voyagers reported by radio several of their discoveries. The temperature outside the cabin, in the open air, was 55 degrees centigrade below freezing—another confirmation of the fact that the Stratosphere has this strange stability of temperature. The temperature inside the cabin is of more practical than scientific interest. It was able to be kept at 7 degrees (centigrade) below freezing —an actively uncomfortable, but not an impossible, temperature. Indeed in their heated suits the Stratonauts should have suffered little real inconvenience. Far more important than the cold inside or out was the Cosmic Ray report. This, too, was radio reported before landing, and certainly showed the ascent had been worth while. The rays were found to be no less than 150 times stronger than on earth. It seems clear from this that such an increase of the charge must have had interesting effects on many of the recording instruments, and it will be especially interesting to see what changes this bombardment produces on living tissue—as will be shown by the hatches of flies' eggs exposed to it, for even if they are sterilized by such a

charge, examination of the germ cell under intense microscopic fields may show modifications and derangements which will be of value to all cytologists and students of cell-life. This record also established still more firmly the present main conclusion about Cosmic Radiation—that it is generated somewhere in outer space, and that outer space must be filled with this immense and intensely penetrating force, a force from which our Stratosphere and the other vaults of the sky protect us.

Meanwhile, as these really "manned" expeditions are clearly immensely expensive, if they are at all to be worth while, the "sounding balloonists" have also continued improving their small instrument-carrying machines. It would add immensely to our knowledge if one could be made to send back constant messages of what was happening to it, so that even if lost its record would remain. Though it seems too wild a hope, yet this has actually now been done. Dr. Benade, an Indian researcher, has made an instrument light enough to be carried by a sounding balloon, and which will send out radio signals all the time telling both how the temperature is changing and how the Cosmic Radiation is increasing. This will not, of course, make manned flights unnecessary, rather it will probably provide fresh information raising problems which only further manned flights can settle. It is, however, fascinating here to see man and the machine in a rightful competition as to which can add most to knowledge

and which can push the frontiers of understanding furthest.

There can be no doubt that every summer season now will see several attempts made to explore still further this new Kingdom of space. America, Russia, and Western Europe are all in the running. Stratosphere exploration has this great advantage that, after all, the frontiers of this Strange New World are always everywhere close at hand—a little farther, it is true, if you start from the tropics, but, even then, never more than what on a level would be the equivalent of a quarter of an hour's ordinary car-ride away, while in the temperate zone, from which at present all the ascents have so far been made, seven miles up may see you over the border.



[*International News Photos.*

A diagram of Dr. Robert H. Goddard's moon-rocket of 1929; similar in essentials to the stratospheric rocket which he is now designing. (See illustration, page 66.)

CHAPTER III

THE USES OF THE STRATOSPHERE

What we may do with it.

THE time is long past when people were quite certain that a discovery was useless unless it had an immediate and obvious practical value. When a rather priggish woman asked Faraday what was the use of his first dynamo, he answered with the counter-question: " My dear lady, what is the use of a new-born baby ? " His answer has sunk into our minds. We know the dynamo was to prove, literally, worth millions. It is so to-day, and it will remain—invaluable, until by pure " useless " knowledge we learn much more about the mysterious world which surrounds us—seemingly so still and inert, but really so full of fabulous energy.

Forecasting the weather.

Stratosphere exploration, however, need not fear that it may be vetoed because it cannot say as yet what it may add to " the benefit of man's estate." True, it will very probably illuminate many obscure problems, and give us fresh insight into the questions so vast that we can hardly imagine our ever being

able to turn them to our minute bodily profit; and this knowledge will be for the enlargement of our minds, not for the lining of our pockets, giving us not new means but a new picture of the universe and of our place in it. But research which leads to that outlook, unlike much other research, which cannot claim such a lofty goal, will nevertheless pay its way all the way.

If Faraday's dynamo was "carrying itself" before he died, we may say modern Stratosphere research will be compelling people to invest money in it before it is ten years old.

The first paying proposition it offers is accurate weather forecasting. The history of weather prophecy has been a singularly humiliating one for the man of science. It has been said there are two great provinces in which science seems to have met with more checks than victories, and they are both of prime importance to man. One is the study of the human body, and the other the weather. Until lately, meteorology had to own that though it did a great deal of useful work in keeping records, still only a little over 50 per cent. was all that the forecaster could hope to score with his prophecies—only a little better than any of us could do without a single reading or observation, simply by guessing.

It was true that men had discovered, by the close of the nineteenth century, that there were vast mysterious spinning movements going on in the air over ocean and continent, and that somehow the actual

weather—gale, calm, rain, cloud, and clear sky—was a consequence of these disturbances. The barometer showed that when the mercury was sinking a " depression " was approaching with unsettled stormy conditions, and when the glass rose then calm was probably on the way. The depression was called a cyclone, because it was a vast circulating disturbance, and its opposite was named an anti-cyclone. Fifty years ago Abercromby had made weather charts—those familiar ovals marked with arrows to show in what direction they were going, and bearing on their sides labels to tell you what sort of weather could be expected on the whole if that part of the great travelling lake of air passed overhead. But what lay behind these disturbances and calms, what set them going? Their movements were very complicated. Often they appeared suddenly, and as suddenly faded out. It began to be clear that they were " zooming " down on us and up again from somewhere else.

It was not, however, until necessity drove men to it, that they went pertinaciously to work to follow up to their lair these invisible but very important raids. During the war the Norwegian weather service found itself suddenly cut off from all telegrams of on-coming storms and weather changes. This was very awkward for Norway, a country with a huge western sea-board and largely dependent on its fisheries. Norway, however, had two enterprising scientists to help her, the Bjerknes, father and son. They refused to sit

down under the deprivations, and, as they could not get any more weather information abroad and on the level, they sent to see whether they could get what they needed along the one route left open—straight up above their heads. The exploration was brilliantly successful. An intensive sounding of the upper air was begun. The number of observing stations in telegraphic touch was increased more than ten times. It became clear, as soon as the findings were examined, that the upper air held the secrets of the weather. Huge masses of air, strangely unmingled and distinct, were slipping and sliding, riding and being overridden by each other high over our heads. Quite simply, what was happening was huge " air-icebergs " were always slipping down from the pole. These collided with warm air masses coming from the South. Their constant invisible jousting—what we may perhaps call the dust and sweat of their unending conflict—came down on us as the weather—fog, rain, snow, and wind. For when the cold air advanced it pushed its way under the warm mass; while, when the warm air made a drive, it rode over the cold mass.

The further details which this radical discovery brought to light are too complicated to describe here. It is enough to say that from that date the weather forecaster has known that his goal is the upper air. His motto now might well be: The higher the better. Now regularly without fail aeroplanes are sent up every day to fetch weather knowledge from the highest

attainable levels. The Meteorological Office in London gets its upper air news every morning from the flying station at Duxford in Cambridgeshire. There, every dawn, as regularly as the Mohammedan ever used to mount his minaret to call the faithful to prayer, an aeroplane rises and climbs to 20,000 feet at least, and now increasingly often goes to 30,000. Electrically-heated and oxygen-respirated, the pilot carries up the thermometer and psychrometer to measure cold and damp. Meanwhile, as he is a trained "cloud naturalist," he notes how the clouds are shifting and what they are doing. This trained viewing by an observer is at present invaluable, and no instrument can take its place. The moment he is down—the flight takes some ninety minutes—his diary is rushed off to the London office. Again at midday he will climb up to his flying look-out and take the air's temperature and note the general outlook.

But that is only preliminary, and far from the best we could have if we chose. So meteorologists hope that soon those governments which want a very valuable service for a very small outlay, will set up a regularly spaced series of observatories round the Arctic Circle, from which points sounding balloons will be sent up into the Stratosphere every day, there to say exactly what is brewing. Then and then alone our weather may cease to be a joke and become a science, and we, to-day, who cannot say whether a jubilee or a test match will or will not get a soaking, will seem as

ignorant as the Romans who did not know of the tides in Northern waters, and were in danger of stranding their fleets when they came out of the Mediterranean.

Surer flying.

Weather forecasting, however, does not end with warnings to farmers, sportsmen, and celebrators. Nevertheless, comparatively few people realize that our modern aviation services, rudimentary though they still are, could not have attained their present degree of efficiency had it not been for this new knowledge of the upper air and the forecasting it permits. We may not as yet be able to say when cloud will begin to form or to foretell a slight rainfall, but we can warn the air-pilot of real dangers—for instance, those intense lunges and drives of air, called "line squalls," which compel most aeroplanes they meet to get down or be swept down.

The aeroplane is doing much to add to our growing knowledge of the upper air, and it is therefore all the more fitting that it should benefit most from the present new knowledge. Without that level of knowledge the running of regular transcontinental flying services would still be impossible, in spite of the mechanical efficiency of the modern aeroplane; the risks and actual smashes would be prohibitively high.

Flying, our quickest transport service, is then another profit which has accrued from upper air knowledge. Our incomparably quicker method of communication,

radio, is even more dependent on further advanced knowledge of even higher spheres of air.

Flight to-day is, for its margin of weather-safety, dependent on continually developed studies of what we may call the foundations and floor of the Stratosphere, and there is no doubt that the farther we can work our way through that floor, the firmer, the more reliable and more extensive, will our protective foresight be. Radio, on the other hand, began and still begins at the other end. The layers far above the Stratosphere, 60 or 100 miles high, first interested the broadcast engineer, for it was on that roof or ceiling—the Heaviside layer—and then on the higher Appleton layer, that the first transmissions, and the ordinary transmissions to-day, echo and run round the earth.

Further Broadcasting.

We have seen that the Heaviside layer, like a Pacific tide, comes daily into the Stratosphere and then ebbs away. That, it seemed, was all that the Stratosphere had to do with radio, and therefore radio seemed only to have a partial concern with our subject. However, lately, through the constant sounding and probing of the radio roofs or ceilings by high frequency waves so as to discover when and where and why they "leak," these echoing layers have been found to be almost as numerous as the roofs of a Chinese pagoda.

The second of these vaults to be found was, of course, the Appleton layer, and that was far above the Heavi-

side, and for a time it seemed that radio plumbing and sounding would be wholly concerned with greater and greater heights well beyond anything we could call atmosphere. Beyond the Appleton layer, riding some 110 miles high, was found yet another, 35 miles farther out, and so it seemed it would go on—for Danish radio sounders found a layer even far beyond the moon, probably a couple of million miles out. It seemed then that though radio roofs might be touched still farther away in space, none could be looked for nearer in to the earth.

That, however, the latest research now seems to show, may be a premature conclusion. For Mitra P. Syam, an Indian specialist, working in the wireless laboratory at the University College of Science in Calcutta, reported in June last that he had found a new "lowest-ever" radio-carrying layer or vault. It seems to lie—at least most of its time—only some 35 miles above ground. It is true that it is not much of a "mirror," and seems to do more harm than good—as a bad piece of glass put in front of a good mirror confuses the perfect reflection. Nevertheless, there it is, whether as a convenience or a snag, whether as a firm-hearing surface or a radio-quagmire in which the message gets bogged and "fades." As low as 35 miles we have come across a layer of air so beaten upon and bombarded by the sun's invisible electric waves of energy that the molecules of that air are electrically charged, and so we have the first radio

roof, if still a very leaky and split roof. Thirty-five miles up is close to the Stratosphere's own roof. Still, if our present calculations, which give the Stratosphere's upper limit as just over 36 miles up, are sound, this, the latest and lowest of radio vaults, is just within our province.

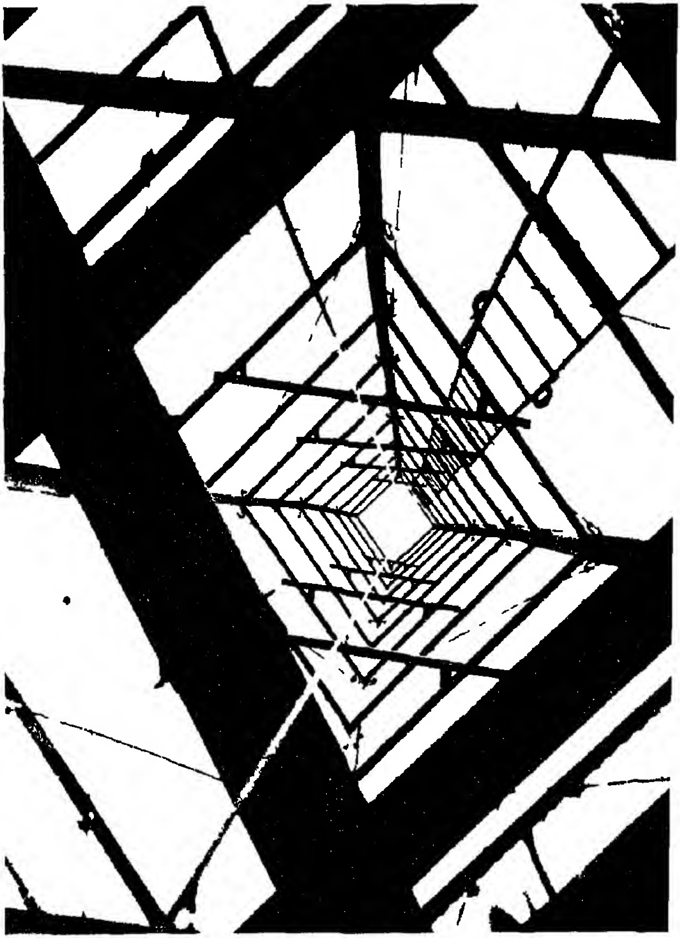
Further radio research may discover even lower layers. The investigations of micro-rays have brought to light already some very queer problems. These tiny rays, it was thought, followed the ordinary rules of light, so if you could see your mark, the receiving aerial, you could send your message to that spot, as at night you can throw a pencil of light rays on to a distant scarp. On the other hand, if you could not see your mark, or at least if the view was blocked by a mountain or other obstacle, your message must also be held up. But lately it has been proved beyond any further doubt that these tiny rays have managed to get where sight on the clearest day simply cannot get, round the curve of the earth itself, to receiving sets between 120 and 170 miles away; indeed there are some reliable reports just to hand of reception over 200 miles.

It is quite impossible to imagine that these small shafts of rays can go through the immense thickness of solid that even that small section of the earth presents as an obstacle to their penetration in a straight line. But on the other hand, radio rays shot off must either be caught by some of the radio roofs or leak off into space and "never be heard of again." It is almost

equally hard to believe that these tiny rays, which behave so like light and are aimed at their mark much as a jet of water may be aimed straight at a garden bed, can really be leaping up to the radio layers we know, the soundest of which is sixty miles high, and coming down again on to the earth a hundred miles away. It seems increasingly likely that here too, as in those first days of radio, the message itself may be the clue to the unsuspected path which carries it.

In those early days Marconi was told by all pure physicists, all the men who should know, that his notion of communicating over vast distances by wireless waves was quite impossible. Such waves must go, not out and about the earth, but out into space, because, of course, there was nothing to hold them in. Neither Marconi nor the theoretical experts knew of the radio roofs. They said such could not exist, and therefore all expense was waste. Marconi was prepared just to see what would happen, and he found together with his message the invisible path it needed. So to-day he and all other researchers with the micro-rays may be finding, not merely a new way of communicating but also a means of mapping new strata in the Stratosphere, the charting of new tides in those huge superimposed oceans of air.

(1) Real weather wisdom—worth untold millions; (2) steadily safer flying; (3) still more and neater ways of constant radio inter-communication, so that, though the "Aether" get jammed and jumbled with



[Wide World Photo

Looking up the tower which Dr. Robert H. Goddard designed i 1929 for launching his projected moon-rocket. (See illustratioı page 56.)

the large overloaded radio-waves colliding with and impinging on each other, yet the tiny micro-waves will shoot through and keep us all in touch—these are the benefits which Stratosphere knowledge has already given us or seems about to yield. Considering the Stratosphere is, after all, only a vast space, which to all our senses seems unbelievably empty, surely it has proved quite astoundingly productive already—an ocean which has yielded an amazing harvest, a distinctly paying proposition. And yet we have only begun to touch the fringe of it. It has already added so much to our power that it must certainly hold the secrets of greatly increased knowledge.

Before, however, we consider what it may hold in new understanding and change of outlook, there is yet one more immense practical power and possible advantage which the Stratosphere may yield us. That, of course, is Stratosphere flight.

Stratosphere Flight.

Stratosphere flight is already the next great practical step forward in flying. Aeroplane designers have already made the first machines to try out on that new "racing beach." Up till now the Stratosphere has been looked upon as the balloon's last preserve. Up there it still kept the lead which the lighter-than-air flying craft won a hundred and fifty years ago, when the hot-air balloons took man for the first time into the sky, while all heavier-than-air flying machines remained

dreams, or were crazy constructions which pitched themselves and their passengers headlong on to the earth.

And when the Stratosphere was discovered and the aeroplane, not long after, was invented, it seemed that these two must continue to be separated. The aeroplane seemed to be as naturally debarred from the sphere of the upper air as the racing motor car is debarred from the sea. Yet, after a few years of the study of the Stratosphere and of further invention with the aeroplane, we seem on the point of launching a heavier-than-air flying machine up on to that upper air which is too thin to breathe, too thin to hold clouds, too thin to be called air at all by any one save a scientist.

The main difficulty the Strato-plane designer had to overcome was the making of a machine which could bear up against air many times thinner than the thick breathable air in which all our flying started and is still nearly all carried on.

Against this great disadvantage a compensatory advantage could, however, be put. An aeroplane's power to bear up and, further, to climb up, depends on the speed it can go, for this, of course, presses its planes harder against the air and so gives it more support. The Stratosphere air, being much thinner, does undoubtedly make it harder for the aeroplane to sustain itself, *if it can only travel at the same pace at which it travels through the thicker air down here.* But

the thinner air not only lets it down more easily, it lets it through more easily also. Hence the upper aeroplane—the Strato-plane—will go much faster, and so be able to sustain itself just as well as the aeroplane down here, because it will be faced with proportionately less head-resistance.

That difficulty surmounted, there remains another, not quite so obvious but more grave. The aeroplane, as has been said, is a stringless kite. Instead of being pulled along by some one on earth, it propels itself by the screws. These have to catch a hold on the air as the wings of the 'plane catch hold of it. In very thin air, then, the screw-blades will be striking upon such thin stuff that they will get little purchase, the aeroplane will get little pull, and it will begin to fall. High-speed flying has, however, already begun to find a solution to this difficulty. That lies in the variable-pitched screw. There can now be fitted to aeroplanes both propellor and tractor screws which begin with one kind of scoop or cut on the air and then, while in flight, the angle at which the screw blades are slicing into the air can be altered by the pilot and they can be made to cut more or less sharply than they were cutting when the flight began.

The greater speed at which the 'plane itself can forge through ultra-thin air, and the more abruptly its screw blades can be made strike on that air, are, then, two ways in which the first great obstacle to Stratosphere flight in a heavier-than-air machine can be overcome.

Yet other obstacles less immediately obvious remain to be overcome, and are being tackled. The problems of keeping the pilot safe can best be solved by shutting him up in his cabin and making him able, like the Stratonaut balloonist or the deep-sea " Bathy-sphere " diver, to carry his own bubble of " home-made atmosphere " with him into these deadly heights. Really a more serious difficulty than how to keep the pilot breathing, is how to keep the engine breathing. For, of course, the internal combustion engine is a greedy breather, as indeed are all heat engines. That difficulty, however, seems also to have been overcome by the supercharger, a device which has helped to break records in car racing.

So the pilot, the 'plane, and the machine may be ready to attempt a new cruise. Any day now we may hear of the first trial run of the aeroplane out on that super fairway that runs round all the world in every direction—the Stratosphere. The speeds which it is calculated may be attainable up there with our present methods of generating power, and translating that power into propulsion, are anything between 700 and 800 miles per hour. When we think of the enormous strain and effort of getting to 400 miles per hour—the present top-speed down here in our thick breathing-air—that extra 300 miles per hour and more added to our top-speed is certainly a big step up.

And there is more in it than that. For, by simply making more powerful engines and keener 'planes, we

will probably never get much beyond the 400 miles per hour already reached, as long as we are restricted to the thick resistant air of the Troposphere. Scientists have for some time suspected that somewhere between 400 and 500 miles an hour there lies very probably a limit to flying with internal combustion aeroplanes. Studies of the way the head-resistance increases as you try and push a boat at higher speed through water, had long shown every mathematician interested in dynamics that you were faced with a very serious obstacle in the natural law, which showed that if it was required to add another knot to the vessel's speed, the resistance, the dead weight of the water which had to be overcome, increased by the cube. Aero-dynamic study of how the air's resistance increases when you reach these unprecedented speeds, of between six and seven miles a minute, shows that here too you may probably be faced by pressures against which no one can say how any aeroplane can stand up. Higher speeds may necessitate radical structural changes, and stream-lining and a wing-design very different from the present types may prove to be the first considerations.

And we have further to remind ourselves that our knowledge of what happens when objects are hurled through the air at such speeds is so slight that we are probably unable to take into consideration, with all our present mathematical method, all the strains and risks that then come into play. Science is never safe

and sure unless based on frequent observation. As we saw, the upper air itself held an immense surprise for informed theorists just as much as for men of common sense. So, too, it is likely that beyond the speed limits which we have already explored and experienced—speeds, we must remember, that no other living being or body has at present attained—there may be sudden increases of resistance and strain like invisible rocks and shoals on which any 'plane must shatter. Actual experiment with models, and also with full-size aeroplanes, in the new wind-tunnels where wind of cyclonic pressure can be shot against the wings, has shown that often no mathematical calculation based on our former observations could say how the 'plane would actually be buffeted and wrenched. So the secret of several mysterious crashes has been discovered.

We certainly do not as yet know all the dangers to which high-speed exposes 'plane and pilot. Here again we have a casualty to report. M. Farman, who, as a young air explorer twenty-seven years ago, was in the first flight of the first true (heavier-than-air) flyers, is now a manufacturer of 'planes, and has for some years specialized upon the production of a Stratoplane. Wings of immense spread, super-charged engine, a four-bladed screw of variable pitch, pilot's cabin air-tight: all these special precautions had been taken. It was the only Stratoplane in all France. On August 2, 1935, the machine showed what it could do, sweeping

up to the respectable—but still preliminary—height of 32,000 feet. Three days after it went up for another trial lunge at the upper sky—and crashed. The machine was shattered; the pilot, M. Cognot, killed. We can only salute one more of the pioneers who chose rather to explore than to be safe.

It looks, then, as though voyages into the Stratosphere are no idle adventures pursued simply because of man's desire to reach any inaccessible place, whether useful or not, whether it be the uninhabitable poles or the unscalable summit of Everest. On the contrary, it seems as if the development of the aeroplane itself, the necessity for room if we are to advance with flying at all, will drive us up there. Speed is the urge, speed is the goal, the hope and the spur of our strange age, and if we are to keep up the speed at which speed increases, it looks as though only by dashing up into and along the Stratosphere can we hope to do so. Pursued by our profound demon of restlessness, the need to go ever faster, we are like flying-fishes which, chased by the larger fishes which prey on them, have been driven to break up and out of their natural element, the sea, in which alone they can feed and breathe and breed, and escape from their enemy by a spurt of flight in the unnatural air above.

Whether people will be more comfortable and more wise when they can leave London after breakfast, take lunch in New York, and be back here for dinner, one cannot say. It is doubtful whether, now we can do

the same trick across the space which separates us from Paris, we are wiser and more at ease than our ancestors who, 100 years ago, were as far from Paris as we are now from New York. What is clear, however, is that the Stratoplane will be the final challenge to all national air forces. If air fighting forces remain national, and nothing but national, then nationality will have reduced itself to its final absurdity. For no fighting air force will dare be without this new weapon, as, without it, a nation would be more helpless against another so armed than is a fluttering sparrow against a swooping hawk. Yet, with air forces riding ten miles high and sweeping forward at 700 miles an hour, a nation (whose whole territory may be no broader than that) which maintains that it can shut itself up in complete independence is as absurdly out of date, from the military point of view, as squabbles and vendettas between the various suburbs of London. So the Stratoplane will give the world's air fighting forces the final weapon which must make them decide to become one force, or to become the final anarchist conspiracy to blow up and crash civilization.

These are ways in which the Stratosphere will complete and bring to a swift end certain developments which the aeroplane hurried up, but which were started by the balloon and the steam-engine, inventions of more than 100 years ago. Besides completing these inventions, the Stratoplane may also start something quite new. That, of course, is rocket flight.

Training ground for Rocket Flight.

Rocket flight still sounds something which should belong to the world of Jules Verne or H. G. Wells and not the world of scientific fact. Yet, of course, rocket flight is already here. Indeed the advocates of rocket flight might claim that their practice and experiments were really more advanced than those of the Strato-planers. For rocket flight has already taken place, while the Stratoplane is yet to take flight in the sphere for which it has been designed. The trouble about our getting the latest news from this quarter is that both these experiments—rocket flight and Stratoplane flight—matter so much to the old Nationalists who control our governments, and the soldiers who serve them, that it is hard to get information about these epoch-making inventions. Experiments have to be carried out in some country, some country, also, where there are first-rate industrial works to turn out the necessary apparatus. Such countries all want any new scientific force to be at their disposal and to be denied to all others. Still we do know the first use of a rocket to drive a car was made in Germany, and shortly afterwards in the same country a 'plane was sent literally rocketing into the air, and the pilot actually alighted safely, though he was found gravely shaken and dazed.

It is possible also that the first experiments in true rocket flight have been made under the shadow

of the German army on an island off the Baltic coast.

Theoretically there is nothing against rocket aeroplanes. The dynamics have been worked out, and there have been societies in existence for several years, both on this side of the Atlantic and the other, with the object of pursuing this method and aim. And what is more, the Stratosphere is the rocket 'plane's true fairway. We have seen that many difficulties both of plane and propeller have to be overcome if the internal combustion aeroplane, driving itself with screws, is to get along at all at that immense, rarefied height of air. It is these difficulties the rocket 'plane surmounts. However much we can vary the pitch of the screws so as to give the blades some grip and purchase on the thin air, however fast the screws can then hurl the 'plane on to that air, in the end, as we climb higher, there must come a range when the screws will whirr as helplessly as a ship's screws whirr when the sea pitches them clear of the water, and when the 'planes themselves, however hard driven, cannot pack under themselves a bearing pressure of air. Then the internal combustion screw-aeroplane has reached its tether's end. It is an air-plane, and it can only plane on air. Beyond a definite height it can no more fly than a stone can float.

It is here the rocket 'plane will take over, for as the aeroplane becomes less and less at home in the upper air, the rocket finds itself more and more in its true

element. The rocket is really unsuited to those levels where the aeroplane functions best. The reason is clear, for whereas the aeroplane needs air resistance, air for its screw to grip upon, air for its planes to bear upon, the rocket needs neither: it is simply embarrassed and checked by any air however thin. For if the aeroplane is a self-propelling kite, the rocket may be likened to a stone or projectile which, instead of being flung or fired from a catapult or gun, flings and fires itself. The screw blades of the 'plane have to have air to grip on. The gasses which drive the rocket do not have to have air to push against. As they explode at the nozzle or nozzles at the back of the rocket they fling the rocket in a straight line away from the spot where they exploded.

They would do this in a perfect vacuum even better than in the thin air of the Stratosphere. For an exploding gas hits out all round at immense speed, and naturally the one solid object—the rocket base—against which it can strike gets hurled away. Sometimes people find this principle hard to grasp. So it may be illustrated by a familiar use of explosives. When dynamite was first used for blasting rock people used to say " dynamite explodes downwards," for it was found that you could place a charge on a rock-face, cover it over quite lightly, fire the charge, see the cover tossed away, and find the rock underneath shattered. The truth, however, was not that the dynamite exploded best down or up, but that, as it was a very

quickly forming explosive gas, it hit hardest against that which resisted it most, in this case the rock, while it flung aside almost undamaged the cover which was light enough to give way. That, then, is the principle of rocket or explosive flight.

It is clear this form of energy must be increasingly used for flight as we invade the Stratosphere. For the natural element of what we may call direct explosive drive is the air on which no screw-blade can catch. The rocket car itself is also best suited to such conditions. For the idea behind rocket flight is to fling the self-launching or driving projectile up into the almost frictionless air and there let it race along like a shell from a gun—for example, the shell of that German super-gun used for the bombardment of Paris during the war, which shot a projectile up in an immense curve so that it fell like a bomb on the city.

Of course rocket flight is a thing, if not of the distant, certainly of the indefinite future. But the Stratosphere is undoubtedly the trial ground and training-ground of the rocket. Up there it must and will win its spurs. Down here it really is not needed and will never probably oust the aeroplane, any more than the super-charged racing car with long wheel-base will oust the taxi off city streets. Each passage way has its appropriate carriage. And, even when the rocket vehicle is a fact, it may have to use planes or "wings" while it is getting out of the air we can live in up to the Stratosphere and beyond, and almost certainly in its

descent to these home levels. It must obviously have some way of breaking its fall before landing. This it might do by firing rocket charges from its prow, and so checking its speed. But even then it would need to spread some sort of wing to prevent it crashing straight down to earth, or it would have to put up some kind of helicopter screw to let it hover.

That is obvious, but the reason why it must use planes in getting up is less obvious but more interesting. Rocket flight, if it is possible at all, will be at speeds, not of hundreds but of thousands of miles per hour. It does not hurt you to travel at such speeds—the earth at present is carrying us through space at a higher speed than any rocket will take us. People at the Equator are being spun round at some three and a half miles per second. But to get to such speeds—to accelerate too fast—that is physically very dangerous. We now know from the record-breaking parachute jumps of John Tranum—who started to fall when four miles up and came within a mile of the ground before he pulled the parachute release string—that you can fall as fast as possible and yet not be killed by the rush. Before he plunged we did not know that. After all, he only fell at the moderate pace first of 144 miles per hour and then, as he shot into the thicker air below, at only 120. It seems pretty clear that if you keep on increasing your speed faster than a stone falls, thirty-two feet per second, you will collapse. A rocket must therefore start up gently on planes if it is not to kill its occupants

simply by rushing them too fast—sweeping them, literally, out of their lives.

Beyond the Stratosphere lie even higher adventures for the rocket, adventures so vast and nerve-shaking that the Stratosphere will seem as quiet, level, and homely as the lawn of a Cathedral close when compared with space voyages, the final aim of rocket flight.

To treat the Stratosphere not as our ultimate ceiling but as floor and platform whence to launch ourselves into real emptiness, absolute space, may seem counting our chickens before they are hatched or stepping on concrete before it is set. Nevertheless, in any review of the Stratosphere to-day we cannot leave out rocket flight, for already chemical and mechanical research has gone so far that it is practically certain (whether we make our first fatal plunges into space or no) the younger generations to-day will see our great loft, the Stratosphere, used for epoch-making rocket experiments—just as formerly men in large empty attics and gardens tried out their first model 'planes. It has already been calculated that a rocket, to reach its full efficiency, has to go at a speed where the ignited gas is leaving it at one mile per second—a speed which would toss you across to New York in under an hour—and a rocket motor is now designed which, weighing only one stone, would develop no less than 200 horse-power. Compare this with our wonderfully efficient petrol motors which can generate an equal horse-power only if they weigh at least some twenty stone, and

whose goal is to be able to yield one horse-power for every pound of their weight, and it is clear why all power experts cannot fail to be interested in the rocket. And interest in the rocket must mean interest in the Stratosphere and increased knowledge and use of the Stratosphere.

CHAPTER IV

THE MEANING OF THE STRATOSPHERE

How the Stratosphere will add to knowledge.

WE have now finished with the Stratosphere's immediate uses. We started with its use as a weather guide, then we saw its radio uses, and finally it had to be viewed, in its lower reaches, as the place of the super-'plane, and, in its upper levels, as the trial ground of the rocket vehicle.

In this final chapter we must see how the Stratosphere will add to our knowledge. There is, of course, in Science never any very definite or lasting division between what is useful and what is simply true. Applied knowledge has time and again permitted further "pure" knowledge to be won, as when the radio "valve," because of its super-power of magnifying minute electric currents, allowed pure researchers to detect the electrical fields that exist in and around our bodies and the cells which make up our bodies.

In one peculiar way, however, the Stratosphere provides quite a distinct "bridge" between what is useful and what is purely interesting, what increases our powers and what adds to our outlook. We may

not be able to do much with this realm, considering its great size and emptiness. It seems, however, that it may be doing a great deal for us.

At the beginning of this book it was necessary to point out how queerly and narrowly we human beings, and indeed all physical life, seem to be confined in this microscopically thin layer of air. Then we saw further that this air not only feeds us but screens us. Now, however, Dr. Simpson, one of our greatest weather experts, seems to have discovered yet another unsuspected usefulness in the Stratosphere. We have thought of ourselves as insects crawling under a sky not merely indifferent by giving us no protection. We talked of the open sky as though we were exposed, unshielded, to any of the derelicts or deluges of space. That seems, however, to be pushing " the inhumanity of nature " too far.

The Stratosphere the Super-Thermostat.

Lately we have known that the heat from the sun may fluctuate. The sun is a " variable star " and increases and decreases in hotness. It is, however, even later that we have found that the Stratosphere can act as a sort of heat-regulator—like a giant Thermostat controlling the warmth for the whole earth. For, according to Dr. Simpson, if the sun increases its heat then the oceans increasingly evaporate, and the vapour rising into the upper air causes cloud and water-charged air to form. This automatically screens off

the sun. Then the fluctuation of the sun's own heat goes back to normal or a little below : at once the upper air begins to clear, the sun's radiation strikes through it and heats the earth, and once more we have the same balanced ration of heat. So perfect is the apparatus that Dr. Simpson believes that if the Stratosphere's temperature continued to be controlled by the water vapour in it, and not by the direct rays of the sun, this earth of ours could keep much the same warmth at ground level, even if it got as little sunlight as Mars gets, or was so close to the sun that it got as much as Venus endures. The peculiar interest of this piece of Stratosphere knowledge—the fact that the Stratosphere probably acts as a sort of " governor " protecting us from extremes on the part of our heat-engine, the sun—is that it adds one more detail of evidence to the study of Fitness of the Environment, *i.e.* how living creatures are fitted into the conditions of this world, and this world is somehow fitted to us.

Nevertheless, as we approach the upper atmosphere we are gaining a realm and station where, though we may discover vast uses, our power to exploit and use this area must yield increasingly to the wish to understand. It is not that such spaces are empty abstractions. That, we shall see, is to misunderstand the Stratosphere, and those other mysterious regions, hitherto overlooked, which our generation is about to explore. Rather is it that these studies are revealing to us conditions so strange, so unlike all we have known

so far, that we can probably never hope "to become native to such air," to live among, employ, and exploit such strange conditions. For that is the first thing that we have to realize about the Stratosphere, and indeed all the upper spaces to which the Stratosphere is for us the threshold—they are not empty, they are crammed full. Where we see least there is most. That may sound too fanciful, and yet it is literally true. As Sir Arthur Eddington has said, we are compelled to bring back into use some such word as "the aether." We cannot go on using instead the word "space" now that we know that there is immense activity and force in this space, or emptiness as we conceive it, and that here is "brewed," as it were, all that we afterwards see and feel as the real and solid. It is a greater mistake to go on calling the aether "space" than it was for Columbus to call America the Indes.

Indeed it is in following up that strange, upsetting, unprecedented notion that we find the chief drive and stimulus behind Stratosphere research to-day. We may add to our powers by knowing more about the Stratosphere; we probably shall get reliable weather forecasts and super-flying; we may learn how surprisingly this film of atmosphere has been "rigged" to keep our delicate elaborate bodies supplied with the very narrow conditions which are all they can endure. But the urge which is sending men up into those dangers, known and unknown, is a keen curiosity about

one of the strangest and all-pervading mysteries. This mystery is so strange because it came upon us so unexpectedly, and because it does seem to establish the fact that, whatever space may be, it is literally the full part of things, and it is perhaps only down here that we have anything approaching a certain emptiness.

This, of course, seems a paradox. Are we not loaded and pressed upon by an aggregate pressure of some fifteen tons all over each of our bodies? Out in space this would be lifted off us. At ten and a half miles high, on the Stratosphere "ground floor," only one-tenth of the atmosphere remains above us, nine-tenths are already clotted below; while, when we get to the Stratosphere's own ceiling, the fifty-mile-up level, hardly more than one part out of 70,000 is still above us. So the Stratosphere partakes much more of the nature of "space" than of the nature of air as we know it down here. But strange though it may seem, it is in "space" that we might be exposed to pressures so intense as to be capable of crushing us to death without our being directly aware of their existence. Other generations could have no idea of the nature of such forces. A force you could not feel seemed to them obviously a force that did not exist. We, however, have X-rays and radium to help us. We realize that, though it would have seemed magical nonsense to our great-grandparents, radium and X-rays can kill us with deadly certainty although we are too coarse to feel the blow as it strikes us.

The Cosmic Radiation.

This mysterious force which Stratonauts have been setting out to follow up is, of course, that Cosmic Radiation to which we have referred before as one of the dangers as well as one of the lures of Stratosphere flight. Now we must say a little more about it, for, beside it, the radiations of X-rays and radium, and indeed any activity we know down here, are all absurdly weak. To-day, with this new knowledge, we are like men who have found a tiny trickle of a stream running through the forest near their village. We are following it up until we have already discovered how, quite a little distance away, it swells to a vast river. We are beginning to suspect that this great surge of force might, if we could penetrate far enough, bring us to the brink of the ocean itself from which all waters come. If men in the future, looking back on the first thirty years of the nineteenth century, try to pick out one discovery which was completely original and most opened men's eyes to the unsuspected forces round them, they may quite well choose, out of our vast store of finds, this one, the discovery of the Cosmic Radiation.

The way it was discovered is in itself a remarkable illustration of the main thing which the Stratosphere, and outer space beyond, has to teach us. This charge of electric energy (for that, in origin, the Cosmic Radiation seems to be) is so immense that literally we could not take it in; we had not the slightest

inkling that such a thing existed or could exist. As Sir James Jeans has said, it is always flashing through our bodies and smashing up thousands of the atoms out of which our bodies are built. Yet we remain as unaware of it as we are of the wireless waves pulsing through the room. Nearly every year we discover that it can penetrate more deeply. A little while ago it was thought these rays were cut off a couple of hundred feet deep in the sea, but now it is known that it is necessary to go 800 feet below water to be "screened" from it, and, to protect anything from it on land, a shelter must be built with walls and roof thirty-two feet thick, and made of solid lead—an inconvenient and expensive "hide." And yet, though it has been pouring upon us and piercing through us evidently since the dawn of time, it is only in our day that we have learnt it was there at all.

Even then it was only discovered by a few men who would keep on asking what seemed to most experts a pointless question. What puzzled these few original minds was not that something unexpected turned up, but that in certain electrical experiments there was always an inexplicable leak. That was all the evidence they had of a super-force, the fact that a little energy would keep on escaping. It was noticed that an electrically charged vessel could not be insulated so that it kept its charge. Nearly every one took that fact for granted. A few who would not take things for granted were puzzled. It is an expensive task (and it seemed

[*International News Photos*

Dr Robert H Goddard with a model of one of his rockets His experiments are now backed by the Guggenheim foundation and Colonel Lindbergh

a useless one) to go on sheathing and shielding a charged vessel so as to try and make it able to hold on to its charge. As we have seen, when it is wrapped round with thirty-two feet of lead, then at last it is practically secured.

Of course long before that it is clear to any researcher that he is on the right track. The charged vessel decharges the more slowly the thicker its insulation. Once that was established, these pioneers in Cosmic Radiation had proved the first part of their strange case. There was around us a piercing energy which could go through bodies and walls, doors and vessels, as easily as sunbeams through a pane of glass—an energy which darted through any electrically charged vessel, even when it was thought to be completely insulated. The next problem was to discover where such a force came from, what source could generate so vast a drive and shock. When we consider that our strongest X-rays can safely be held up and shielded by a thin armour of lead, a bombardment that could pierce thirty-two feet of this metal, the densest radio-armour-plate known to us, must have a tremendously powerful source. For a year or two some researchers thought that such a source might be found in the radio-active centres on the earth's surface. But observations on the top of the Eiffel Tower by a scientist called Wulf, and the researches of Gockel, who went in a balloon with instruments up to 15,000 feet, showed that the earth could not be causing these rays, but that

they came from the sky, for the charge increased as you rose. So violent thunderstorms were the next possible source to be studied to see whether the biggest lightning-flash could give off such a shock. Again, even the most violent lightning was found to be too weak to account for such a force.

It was clear, then, that the shock was coming from outside the earth. The only thing to do was to get up into the highest possible air and see whether the charge went on increasing. High balloon flights made with electroscopes, chiefly by a Dr. Hess, proved that the earth was certainly not the cause of this disturbance, for the higher you went the more powerful it became. Many of those interested had thought at this point that perhaps the Stratosphere itself, or the even more highly-charged air above the Stratosphere, might be the source of the rays. Hess, however, boldly committed himself to the opinion that "a radiation of very highly penetrating power enters our atmosphere from above." That opinion was confirmed by the work of Kolhörster—one of the most thorough research-workers—and it is now accepted.

These researches have, however, far from clearing up the mystery, only made it greater. Indeed it looks increasingly likely that here in the Cosmic Rays we have stumbled on one of the prime mysteries of the whole material universe. The various theories advanced by those who know most about these rays show that we are "up against" a force so unsus-

pectedly unprecedented that no one, however informed, can really have at present a clear and adequate idea of its nature. For example, Dr. Millikan, who has done as much work on them as any man, believes that the only event that could account for such a " thunder-clap " of energy, such a shock being given off, would be the creation of matter in some invisible depths of space by the condensation energy. Other experts believe the shock is the " echo " of matter coming apart, literally being blown into nothing but energy. The Abbé Lemaître, the brilliant mathematician who has done so much to give us our present picture of the " expanding universe," makes an even more amazing suggestion, that the Cosmic Radiation is another sort of echo, an " energy-thunder " still rolling round the universe from that first moment when the universe " exploded " and began to expand. Professor Milne believes that the universal gravitation which acts throughout space would be enough to pull and drive particles with sufficient energy so that they could account for the force which the Cosmic Radiation displays. Just at present other researchers are inclined to think that perhaps when a star displays its utmost energy, when it becomes a super-nova, when, in a moment, it bursts into explosive splendour and the cosmic bonfire rages for a few weeks, then perhaps cosmic rays can be created.

There seemed to be some evidence that the days when the latest new star, Nova Herculis, was raging

most violently the Cosmic Radiation records showed an increase, but other observers and recorders believe these fluctuations of the star and the Radiation cannot be really connected. It is a chance agreement and only apparent. It is clear, however, from the variety of these views and the authority of those who hold them, that we are here faced with the strangest of material mysteries, if indeed it can be strictly called material at all. It is also clear that why expert opinion is so much at a loss to agree as to the explanation of even the source of this super-energy is because we cannot experiment with the rays—we cannot even go near to any of their possible sources. It is here, of course, that the Stratosphere comes in as an essential stepping-stone, and we have seen how the latest Strato-flights have added to this particular knowledge.

It may seem rather absurd to suppose that by going ten or a score, or two score, miles high we could really add much to the knowledge we so much need of forces which are certainly not generated even in the solar system, even in the fiery depths of the sun itself. What is the use of our creeping up toward the surface of our film of atmosphere when the energy we are trying to track has its sources in fountains of fire or oceans of space to which, even if we could travel in a rocket—travel even with the speed of light—the distances are so great that a million and more years might pass before we neared the goal? Surely some mollusc, creeping out of the seashore sands of the Nile's farthest fringe of

Delta, has a better chance of reaching Victoria Nyanza? That question, natural enough, shows nevertheless that those who ask it have misconceived our position and do not understand how our knowledge of the upper air has changed our outlook. The Stratosphere and the vaults above it, we now realize, mean far more than a "tailing off" emptiness—an ebbing away of air until we pass into those eternal silences and vacancies which used so to frighten early astronomers.

The Stratosphere and beyond are not merely places with strange and distinctive characteristics of their own. They are literally and very usefully a roof and vault above our heads. We have seen how lately we have discovered that the Stratosphere acts as an automatically opening sunshade if the sun gets really hotter, and how it can increase the quota of heat we receive, by acting as a blanket holding in the heat, should the sun's actual output temporarily show a decline. For long we have realized that we are always being pelted by meteorites, cosmic shot and shell of stone and nickel-iron, but that so efficient is the torpedo-net spread above us that hardly any of these "slings and arrows of outrageous fortune" ever succeed in getting through: they are all, except in extraordinarily rare cases, rubbed away to fine harmless dust before they get near us. It is, however, only with the discovery of the Cosmic Rays that we have found this other and even more important use of the upper air as a roof. The Cosmic Radiation undoubtedly is still very powerful

when it reaches our thick breathable air, but it is really by then, owing to our super-shield, only a shadow of its real self, or perhaps one should say, only an echo. In coming through the shield and screen the original charge strikes against the electrically charged particles of this our upper atmosphere, and what comes down to us is only an effect of this collision, a secondary radiation. No doubt this is fortunate, probably essential for us. We probably could not live in that tornado of energy any more than we could live exposed to super X-rays. Still science wants knowledge, not safety. It is determined to understand, even at the risk of destruction. Hence the urge to get still farther up into the Stratosphere. For it looks as though the Cosmic Rays may pass from their mysterious sources clean through space, unchecked, pure and native as the moment they rushed out in their pristine energy. They may only suffer their first check and degenerative change when they strike upon our protective roof of atmosphere. If, then, we could climb up near that roof we should be able to study them as they actually are, and not only the distorted ricochets and reflections which are all that reach us here.

The Stratosphere leads to where things really happen.

This, then, is the daring ambition, the chief prize, and the tremendous possibility of knowledge which is driving men to scale the sky. We used to think of balloonists rising into a rarer and rarer calm where

death came upon the brave men who went too close to the ultimate peace. It seemed really very little use they should so gamble with death. But there death seemed hardly more than a quiet friend who constrained them not to return again to all the storm and tempest they had left below. Stratosphere knowledge has already as completely reversed that picture, as it has reversed our idea of the temperature conditions in those regions. We now realize that it is down here that man lives in a " close," and, further, he lives under an impalpable glass-cover, and is so kept in quiet and stillness and a comparative emptiness. While it is up there, beyond the frontier, beyond the great dyke of the Stratosphere, that may be felt the thunder and roar of the untamed energy of the outer universe. Of course when we can scale the Stratosphere we shall not have crossed the whole divide, climbed clean up to the top of the cosmic-sea wall and seen, without any breakwater or breastwork, out on to that ocean of energy in which all the suns and raging stars are but mist and spray. But we shall be like men who, in a typhoon, creep right under the lea of such a wall, that they may hear the Titan force raging just the other side, shaking their cover like a shell, and so gauge its strength.

How through the Stratosphere we are entering a new world.

Here, then, to-day we leave the Stratonauts, and, even while we review their rapid triumph, still further

explorers launch away for the front, the only front worthy of man, the cosmic adventurer. Exploring is over, on the level. Only two generations ago the American motto could be "go westward." To-day the only motto for west or east, for the old world or the new, is "go upward." Frontier advancing, that too is over on the level. To-day the only frontier which has any reality—which is not a fatal return to savagery—is humanity's common frontier, the frontier of the upper air, the Stratosphere. To-day through this exploration we are launched on a new high adventure which may be compared to Columbus's when he struck out from the old world, worn out with its conflict, and found not merely a new world, but a new lease of life for the old.

The spheres above us we thought were empty. We have already found they perhaps alone can claim to be full. But can they ever add to our world, the world we have always known and to which we seem for ever tied? Yes, for through the intense forces, which we can at present study only by Stratosphere exploration, we are being brought to a real awareness that the familiar world, which we have treated as the only solid reality, is only a thin slice of all the reality pressing and surging about us.

In most physics museums now there is a chart which is essential to any understanding of the radiations and forces surrounding us. It is a wide band divided into octaves. In the centre is a little belt or

slit, which includes all those radiations which our present senses translate as light. Right and left stretch away octave after octave of radiations every whit as " real " as that tiny belt which is all our senses take in. " Below " are the wireless waves: " above " stretch the X-rays going on till we reach the fabulous energy and " hardness " of the Cosmic Radiation.

That is the present-day picture of the physical universe. The little world of common sense, as compared with that chart of what actually exists, is more narrow, more inadequate, more false than was the picture of the world as a flat dish, which held the field amongst men of common sense before Columbus and Magellan showed that the world was actually a sphere. Before their time men had calculated that the earth probably must be a ball. Rationalistic common sense had no use for such theoretical fancies. Rationalistic common sense dismissed such absurd deductions with the clear and humorous remark that if there were " Antipodes," then down there men must walk upside down. What theory could not do, voyages of experiment succeeded in doing. To-day it is the flat earth people who are mocked by common sense.

So to-day theoretical physics cannot make men of common sense realize that really they go about in blinkers, and what they call reality—and all reality—is a narrowed distorted view, taken through a single slit, of all there is. That is the fact, but men cannot be made to understand how partial their senses are.

As Columbus and Magellan widened the minds of the men of their age, when the astronomers and geometers of that time could not, so, in our generation, the voyages of their true successors, the Stratonauts, will, it seems, by the way they bring back proof of that intense force, this ultra-hard radiation, make it possible for us to realize the immense width and range of the universe about us. So the Stratosphere, though it seems a vast vacancy, may actually add indefinite realms to "man's estate" by making him realize how little he has known up to the present about those forces which, though so recently discovered, have always been pressing close about him—"closer than breathing, nearer than hands and feet." Great as its other yields may be, that must be greatest of all the gains of Stratosphere research.

THE END

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